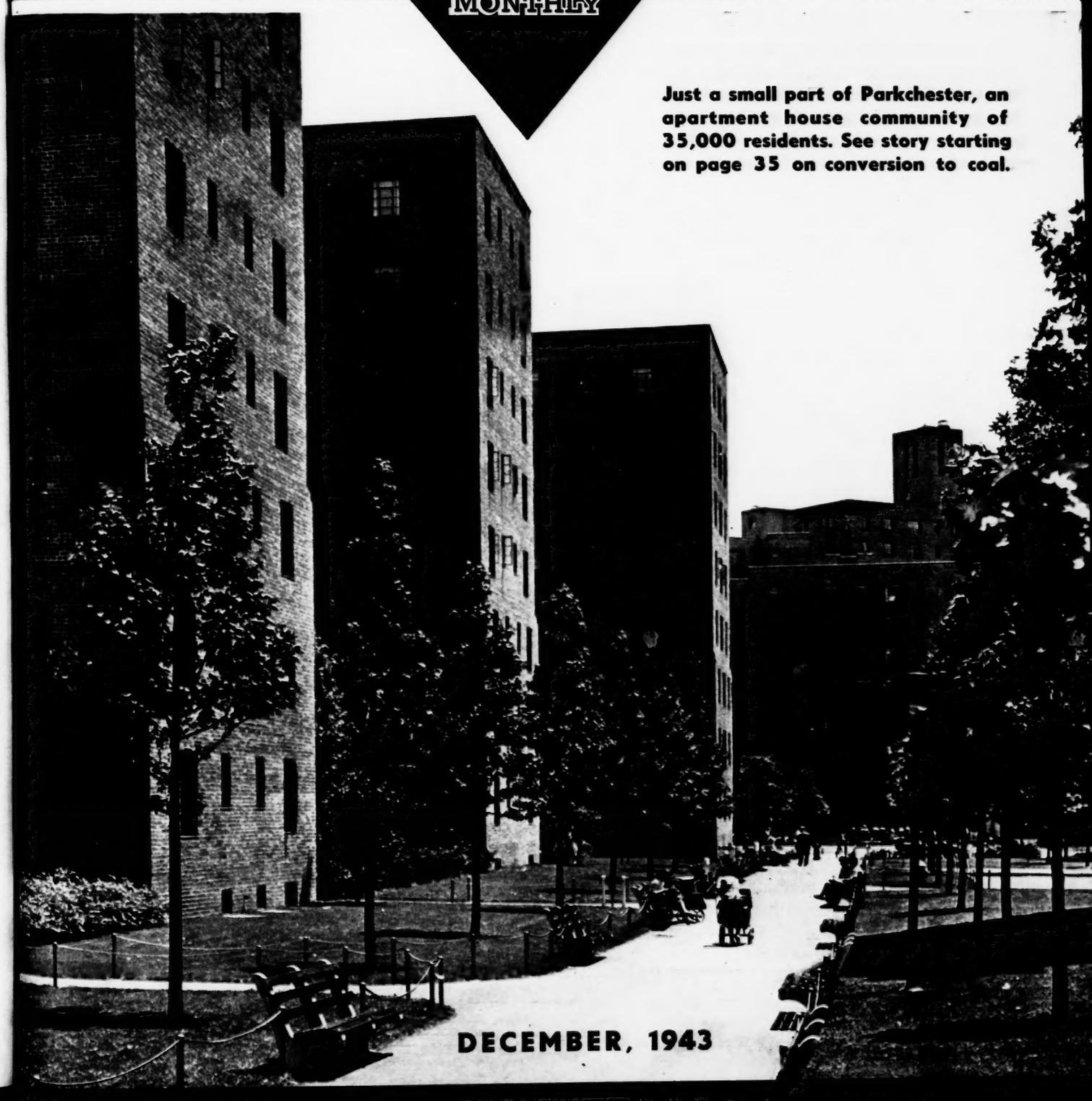
JAN 7 1944

HEATING AND VENTILATING

THE AIR CONDITIONING MONTHLY



Just a small part of Parkchester, an apartment house community of 35,000 residents. See story starting on page 35 on conversion to coal.

DECEMBER, 1943

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USAIRCO

BLOWERS • WASHERS COILS

The big task now is to get the job done quickly, efficiently—to get the types of blowers you need to produce the result you want.

USAIRCO can meet your needs now with a complete line of blowers—the result of twenty years of experience in the design and manufacture of air handling equipment.

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Write today for complete details, prices and delivery dates. Individual catalogs and ratings on all USAIRCO units are available.

UNITED STATES AIR CONDITIONING CORPORATION

Manufacturers of the most complete line of air-handling equipment. Factory representatives in principal cities.

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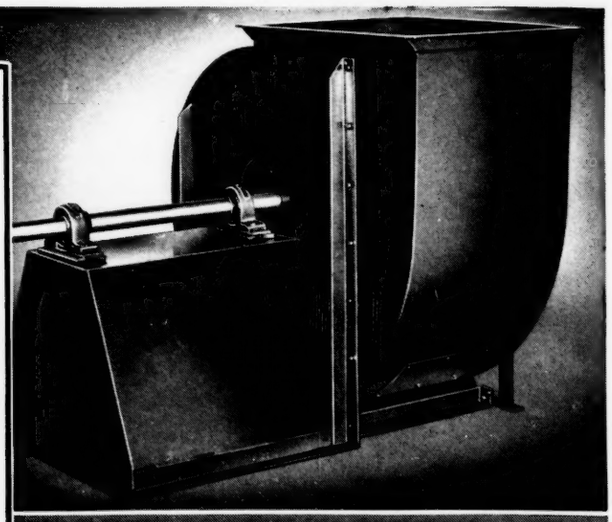
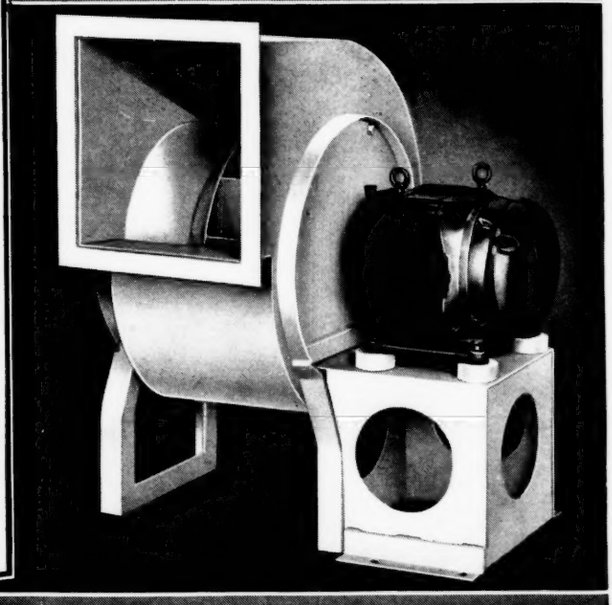
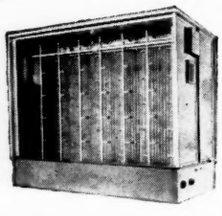


HEAVY DUTY BLOWERS

For industrial and commercial applications USAIRCO has a complete line in all popular arrangements. Pictured above is arrangement number one Blower, with both bearings outside air stream.

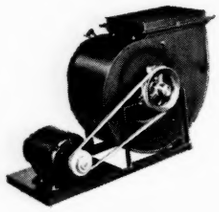
Below is arrangement number four Blower. Available in both backwardly inclined blade and forwardly curved blade types—sturdily constructed for industrial and other heavy-duty requirements.





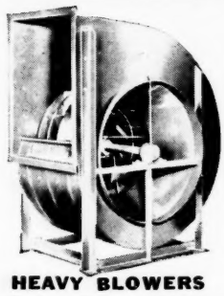
AIR WASHERS

Single and double stage air washers in various capacities for all needs. Used in installations where dependable equipment is required for air cleaning, cooling, humidifying or dehumidifying. Air Washers operate with cold water or refrigerating apparatus.



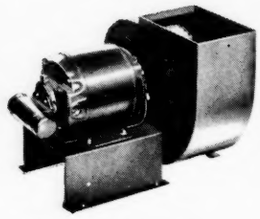
"E" BLOWERS

Belt-driven exhaust blower for light duty work where static resistance is low. Type "E" Blowers are easy to service; are available in several discharge arrangements. An adjustable pulley permits 30% speed variation to handle air as required in different installations.



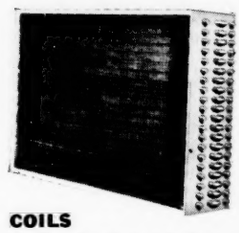
HEAVY BLOWERS

Backwardly curved blade type shown (also blowers with forwardly curved blades), available in types and capacities ranging from 2,000 to 70,000 c.f.m. Used for large scale air handling jobs. Made in single and double inlet, and in varied discharge arrangements.



"SU" BLOWERS

Direct-driven exhaust blowers are designed for use where space is limited. Built strongly, mounted rigidly to prevent vibration. Slow speed motor operates the wheel. Efficient for exhaust applications in warehouses, factories, barracks or mess halls.



COILS

Cooling, heating and air conditioning Coils—fin type with high heat transfer efficiency. Now constructed of steel to conform with wartime regulations.

HEATING AND VENTILATING, *formerly*, HEATING AND VENTILATING MAGAZINE, published monthly by THE INDUSTRIAL PRESS, 148 Lafayette Street, New York 13, N. Y., U. S. A. Subscription rates: United States and Canada, $2.00; Foreign, $3.00. Single copies, 30 cents. Vol. 40, No. 12, December, 1943. Entered as second-class matter, April 18, 1925, at the Post Office at New York, N. Y., under the act of March 3, 1879.

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The Air Conditioning Monthly

FOR

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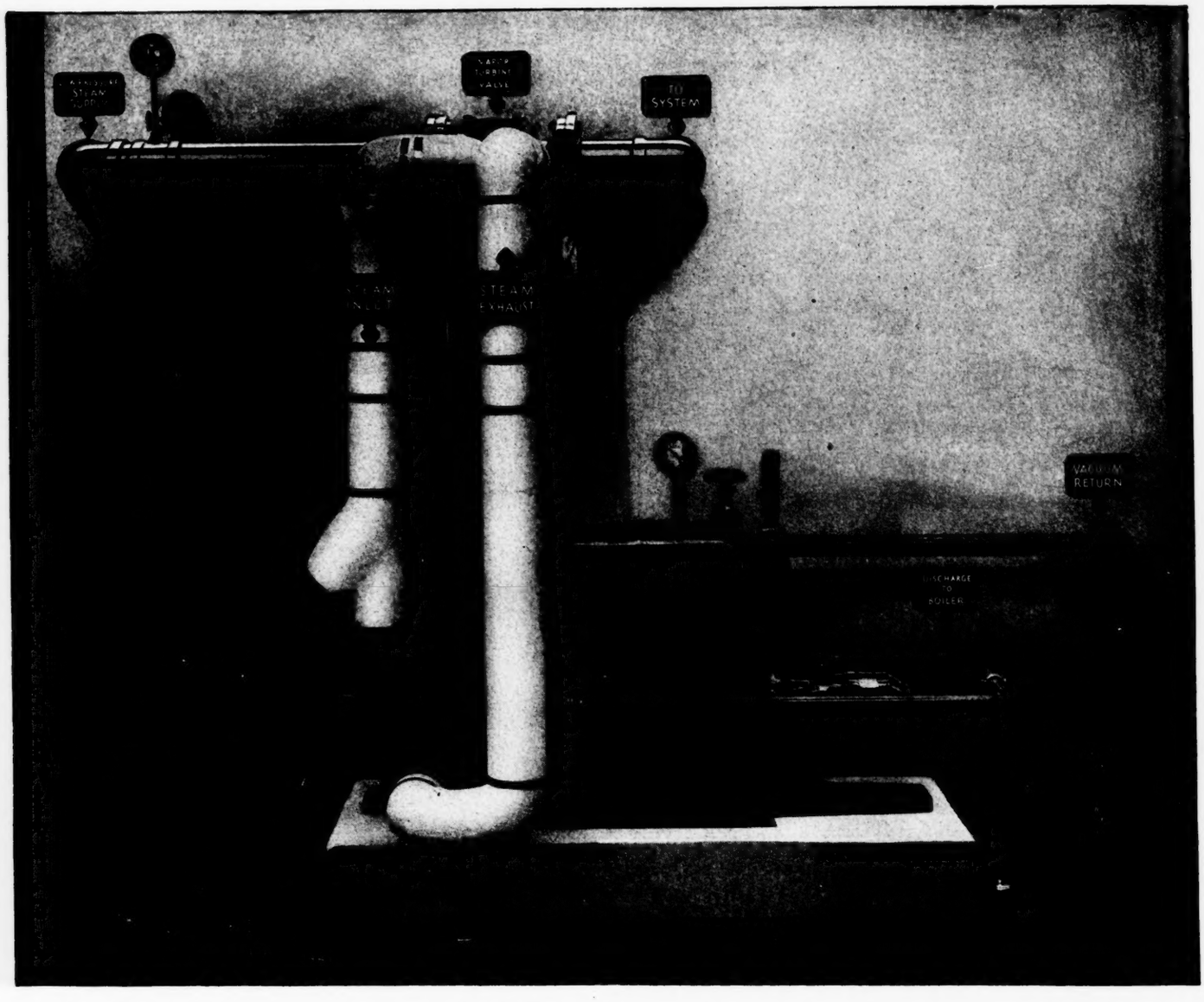
Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY

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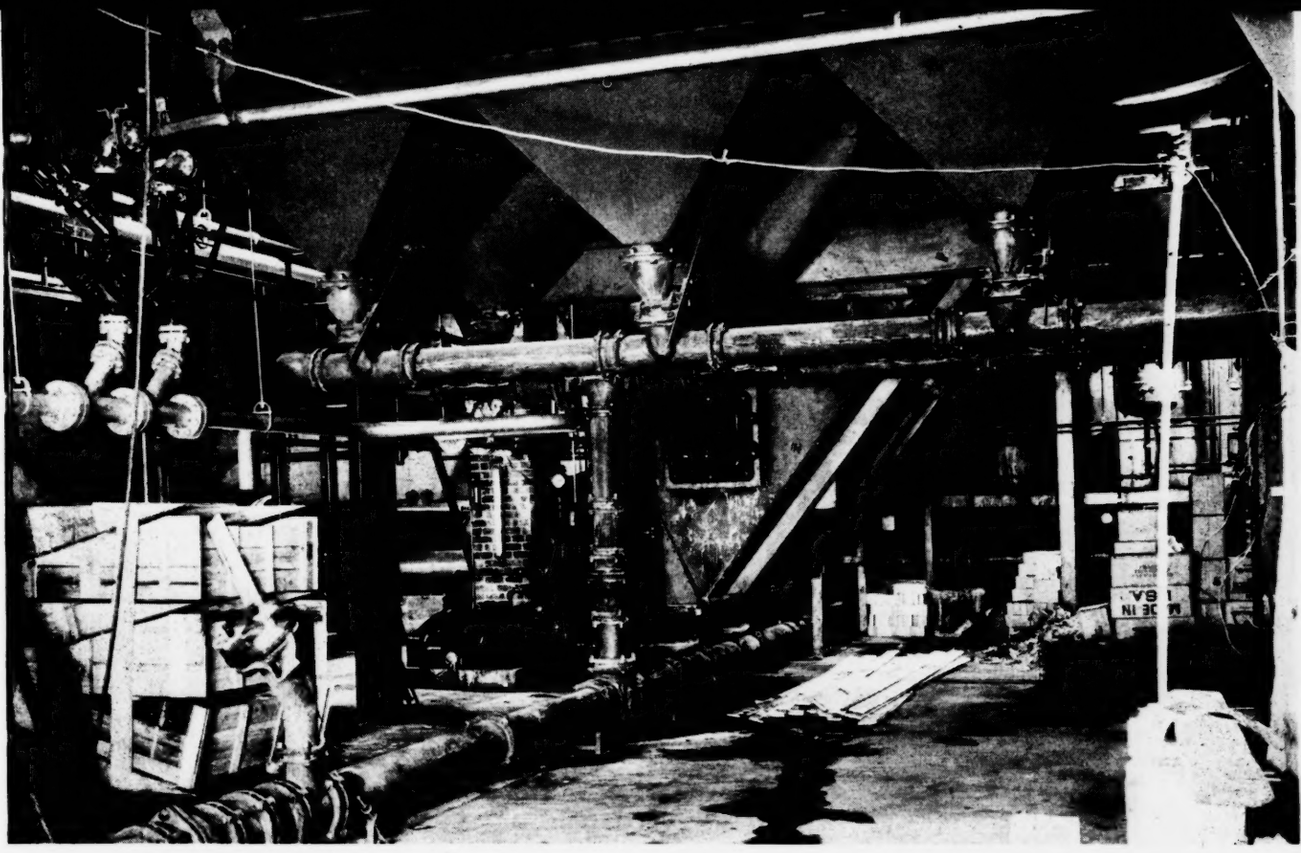


Arrangement of ash conveying tubes and equipment. In center is main combustion chamber hopper for one boiler while above are 6 small soot hoppers. Air draws outgoing ash through the 8-in. heavy cast iron pipe line on the floor. Below the soot hoppers are the manually operated hopper gates.

PARKCHESTER CONVERTS TO COAL

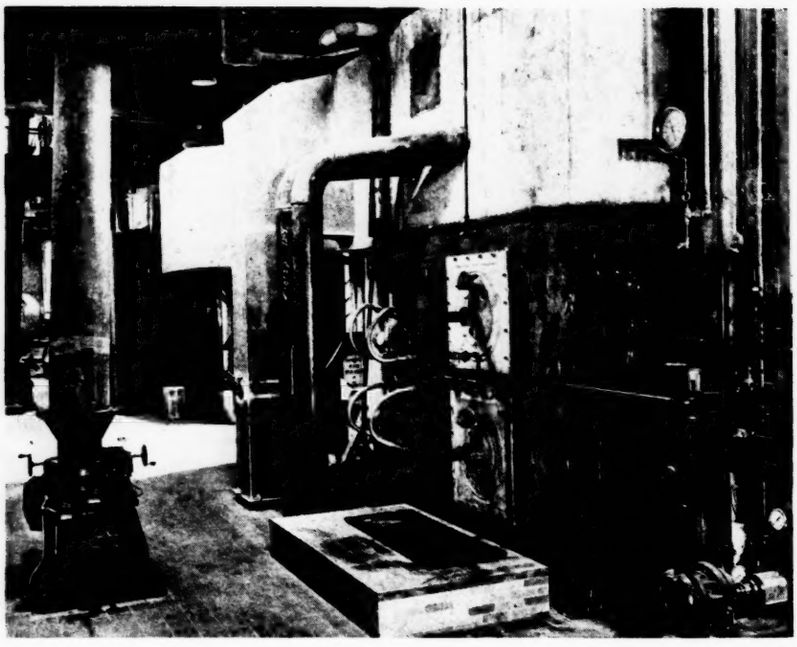
Apartment house community of 35,000 residents changes from oil to coal firing at its central heating plant.

T. F. J. MOFFETT

PARKCHESTER, the huge apartment house community owned and developed by Metropolitan Life Insurance Company in Bronx Borough, New York City, has converted its central heating plant from oil firing to an arrangement which permits the use of either oil or pulverized coal, or a combination of both, as fuel for the steam generators. The purpose was to comply with government fuel supply orders. When planning the conversion, the consulting engineers decided to burn pulverized coal. Some 35,000 tons of coal will be required per year to replace the 7,500,000 gallons of oil previously consumed, and an annual fuel saving is expected.

The central plant furnishes all steam for heating and domestic hot water for 35,000 residents as well as all commercial establishments in connection with the development. Steam is distributed through high pressure street mains and is reduced to low domestic pressures at each building. Each of four Foster Wheeler water wall steam generators in the main plant has a nominal capacity of 100,000 lb of steam per hour at 100 lb pressure.

When completed, arrangements for receiving and handling both coal and oil fuel will be extremely flexible. At present, fuel is delivered by truck, the oil tanks are filled from a sidewalk box, and coal is dumped into a street hopper. Plans are made to receive oil in tank cars and coal in hopper cars on a siding across the street from the heating plant, connecting the present facilities through a tunnel under the street. Run-of-the-mine coal will then be dumped into a track hopper and conveyed by an apron feeder to a 24-in. troughed belt conveyor through the tunnel to the new coal handling system designed to handle 50 tons per hour of the run-of-the-mine



Equipment in front of one of the large steam generators. Automatic feeder at left delivers coal to pulverizer on floor below. Downfeed pipe from roof bunkers connects to the top of the feeder. Two pneumatic feeding tubes (center) carry pulverized coal to the combustion chamber. Rectangular insulated hot air duct, in back of coal tubes, is for preheated air to the entrance of the coal conveying tubes. In center foreground are the outside connections to two oil firing units. Motor driven oil feed is at right.

coal weighing 50 lb per cu ft. Fuel oil will be carried through the tunnel by a pipe line connecting with the present 8-in. fill line serving the distributing system.

Ash, together with accumulations dislodged by soot blowers, is removed from hoppers by an 8-in. discharge pipe to a vitrified glazed tile silo outside of the building where it is stored bone dry until removal. Ash being discharged is rolled through a long drum and dampened enough to prevent dust when the ash is discharged into a truck backed under the silo.

Tramp Iron Removed

Coal is now fed by gate from the street hopper to an inclined 24-in. troughed belt which conveys it to a crusher in the building where all lumps are reduced to not larger than ¾ in. Before dropping into the crusher, coal passes over a magnetic pulley where any tramp iron is removed. From the crusher, the coal falls into the boot of the bucket elevator and is lifted about 90 ft to the top of the coal bunker; it then discharges onto a 24-in. horizontal troughed belt conveyor running down the middle of the full length of the storage bunker. From this belt, coal may be discharged at any desired point in the bunker by means of a self-propelled automatic belt tripper moving on rails.

The bunker, of 2,300 tons capacity, is constructed of reinforced concrete. As originally designed, a steel bunker of the suspension type was to be installed. Shortage of steel made a change in material necessary. The bunker is 135 ft long, 25 ft wide and 42 ft deep to the bottom of the hoppers which are 15 ft deep. The bottom consists of four self-cleaning hoppers each with an 18-in. discharge gate.

Stored coal drops to attrition pulverizers in the sub-basement, to be blown up through 10-in tubes to burners at boilers on the floor above. From the bunker, coal gravitates to variable-speed feeders above the pulverizers.

Four attrition type pulverizers have been installed, one unit for each boiler. Each pulverizer has a discharge outlet that connects to two 10-in. tubes running to boiler burners. Each boiler has two burners, installed centrally one above the other.

Discharge pipes rise from a twin or Y-connection in the sub-basement to form high loops or goosenecks on the floor above. They drop into top inlets for pulverized fuel at each burner. These coal tube connections at the boilers are enclosed by the windbox housings which surround the burner bodies. Provisions have been made to install coal weighing scales. At present, they were omitted due to equipment limitations.

The pulverizers are large drums having interior revolving discs holding swing hammers for the first impact stage; attrition pegs and blocks are in the next compartment for final powdering. A powerful fan on the discharge side draws the pulverized coal out of the mill and supplies air to move the coal through the burner supply tubes. Centrifugal action within the pulverizers throws aside all coarse grains of coal for regrinding. Only fine powder is drawn into discharge pipes.

The pulverizer fan supplies about 10% of air required for combustion when at full capacity. Secondary air is drawn from the ceiling area of the boiler room, passes through the preheater which is part of the boiler design, and continues through the air duct to the windbox at the burners. The secondary air is fan-driven, and the supply is carefully regulated both by the design and adjustments at the burners. Automatic controls register on dials and charts on the instrument board.

Oil Storage Tanks Remain

The original oil storage tanks remain, with probably a small standby supply of fuel oil. This provides a spare fuel for emergencies. When fuel supplies will be plentiful, the fuel selected will depend on the immediate economic conditions. To change over to oil, the oil burner casing and diffuser nozzles are moved ahead into the center of the combination burners. The pulverizer motors are shut off, the oil diffuser is placed back in the burner, the oil pump

is started, and the oil fire is ready as soon as the oil flows. Oil and coal may be burned at the same time, if desired.

Combustion is efficiently maintained by automatic air-operated combustion control equipment which alters the rate of boiler steaming by varying simultaneously the fuel rate input and air supply while holding an approximate balance between these factors. Fuel valves are controlled for oil. With pulverized coal, a control drive unit connects to the variable speed drive at each pulverizer feeder. Low rating dampers are controlled through cable connections.

Ash Removal System

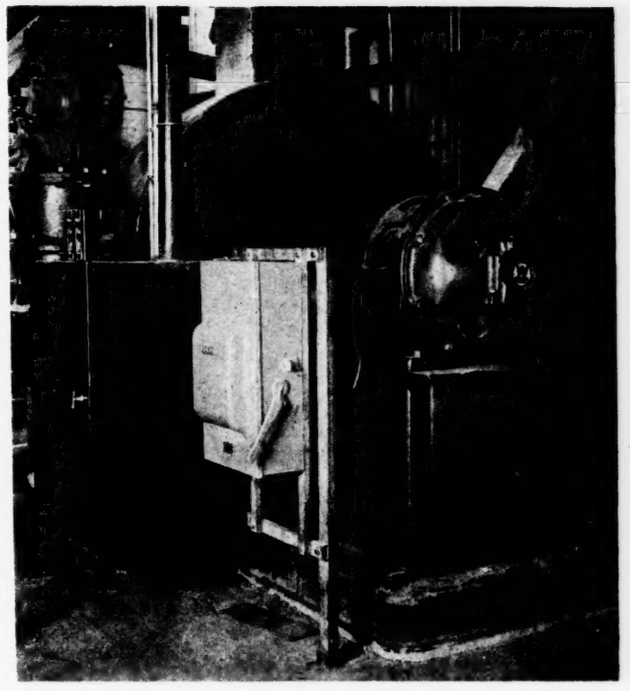
The ash removal system consists of Durite iron conveyor pipe line and branches, an air-tight receiver, an automatic discharge gate at receiver bottom, a secondary dry separator, an air exhauster and an air washer. This specially hardened pipe is to resist abrasion. Heavy impingement plates, which are easily replaced, are located at critical turns. Air-borne material is intercepted by the receiver and is periodically discharged to the storage bin. An air washer removes the remaining dust from the air before discharging it to the atmosphere.

A Venturi exhauster of the multi-jet type, is electrically controlled. The operator opens and closes a 2½-in. steam valve on the line to the exhauster. The multi-jet device draws a large volume of air out of the receiver and the inrush of air closes a swinging discharge gate at the receiver bottom. A high velocity air flow starts through the main conveyor pipe. The average full load capacity of the system is specified at 10 tons dry ash per hour. The manufacturer states the steam consumption will average 360 lb per ton of dry ash.

When the steam exhauster jets at the receiver are placed in service, they operate about 90 seconds and then shut off for 5 seconds. During the "on" period, the inrush of air carries ash and soot from the various intakes. Air and ash enter the receiver tangentially creating a whirling action which, with the aid of baffles, separates the ash from the air. The main conveyor line drops into the basement and connects to the ash intakes. The air-operated steam valve is started by manually controlled remote switches in the plant. The discharge gage opens automatically when the motorized steam valve is closed for the 5 seconds. But when the multi-jet exhauster begins to operate again, the inflow of air closes the swinging discharge gate and the atmospheric pressure differential holds it closed. During the 90 seconds "on" period, the ash accumulates once more at the receiver bottom.

Air Washer Catches Dust

Although some fly ash will go out with the air exhaust, it must pass through the air washer, which also serves as a silencer. A secondary dry separator



One of the attrition type soft coal pulverizers set on the basement floor below each boiler. Twin connections for the two pulverized pneumatic conveyor pipes appear at left.

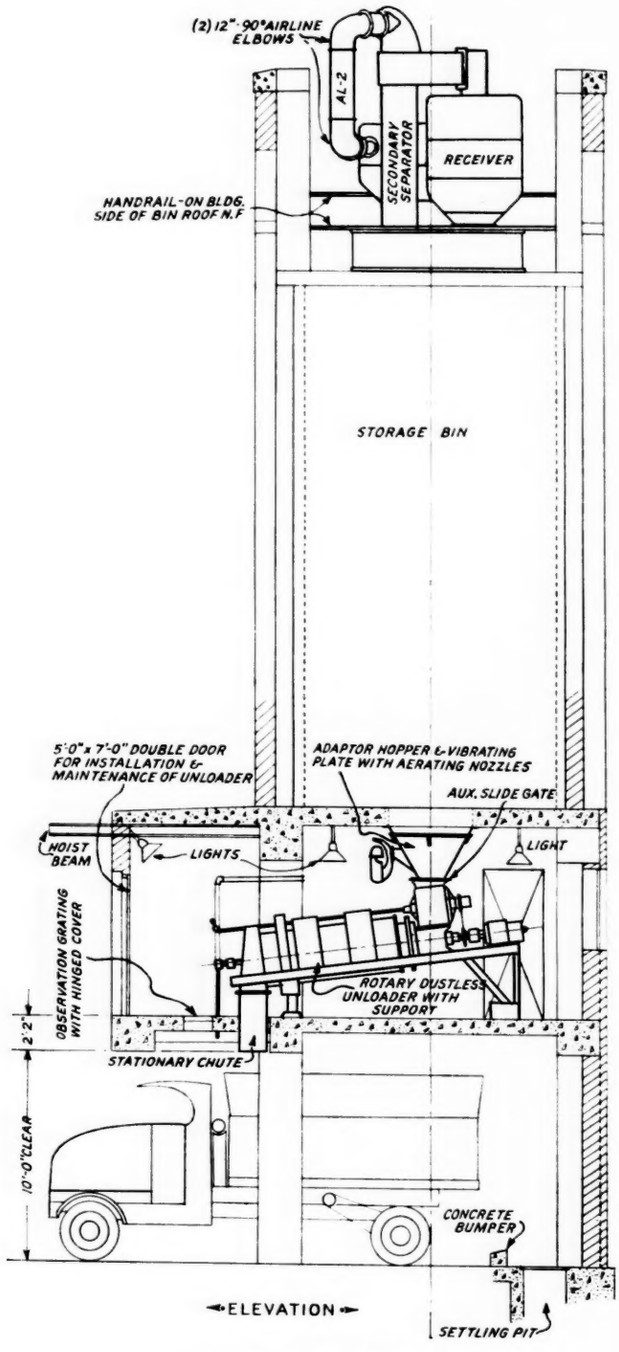
between the primary receiver and the steam exhauster, has a swing discharge gate at its bottom. Specifications describe the air washer as a multi-stage cyclone type, constructed of heavy duty Durite sections with exterior flanges and bolts, provided with bronze tangential water spray nozzles, a discharge spray arrestor, and hinged access doors. An automatic water flow control in the supply line to the washer is electrically interconnected with the air-operated steam valve, but in such manner that this control prevents the conveyor from operating unless there is sufficient flow of water in the air washer.

Units Easily Disconnected

All conveyor pipes and fittings, and the primary and secondary receivers, are of Durite iron with exterior flanges and bolts at every joint. Any part of the system can be disconnected in a few minutes. Conveyor lines are exposed on the sub-basement floor, resting on cast iron supports with adjustable roller saddles. Six 8-in expansion joints are provided for the main line and a number of 6-in expansion joints on the branches. The 8-in. and 6-in. 90-degree elbows have access ports with wing-bolted covers and gaskets. Each elbow has two flat impingement plates, 2-in. thick, quickly removable.

In addition to the 8-in. conveyor pipe, there are approximately 320 ft of 6-in. branch lines connected to lower drum and air heater hoppers. Another 115 ft of pipe and fittings connect to dead pockets at lower boiler drums and to the ash hopper at the stack base. The 8-in. main ash conveyor line serves

the four ash pit hoppers at the boilers. These hoppers, approximately 10 x 16 ft at the top and 12 ft deep, reach down almost to the floor level below. They are made of ¼-in. steel plate with reinforcing and supporting members, and include slip joint ex-



Detail of an ash bin.

pansion seals at the lower header. Each ash hopper has two water-cooled doors, vertically operated by hand winches, and has a 10-in. lining of insulating brick and fire brick.

Ashes are discharged by gravity into 24 x 24-in. grid feeding hoppers. That is, the large hoppers empty into smaller ones protected by grids which hold out clinkers. These parts can be inspected easily. A cross section of one of the hoppers is illustrated.

The 8-in. line has the steam exhausted at the receiver over the ash storage tank. Air for the conveying system comes in at the far terminal of the main line or its branches through air induction fittings having automatic operating check valves. The conveying air is room temperature air drawn directly out of the basement.

Reinforced Concrete Replaces Steel

The ash storage bin of 65 tons capacity is approximately 25 ft high and 13 ft in diameter. It is part of the unified ash disposal system as supplied by the manufacturer. Ordinarily it would be supported on steel columns and framework, but due to material limitations the supports are of reinforced concrete. Bin walls are of 6-in. thick glazed vitrified tile blocks having ample interior air spaces for insulating purposes, and are very effectively bonded and reinforced. This material is fireproof, acidproof and weatherproof.

The well vented storage bin prevents an accumulation of explosive gases. The vent includes filter bags. As ash is stored dry, a vibrating discharger is included for the feeding hopper between the floor of the storage bin and the feeder of the dustless unloader. The feeder is enclosed by tile walls and is provided with doors, windows and access ladders. The system has a rotary dustless unloader which at full capacity can handle about 25 tons of dry ash per hour. It calls for a water supply of 40 gpm at 15 lb minimum nozzle pressure.

Ashes Dampened Thoroughly

The unloader may be described as a mixing or dampening machine for the dry ash, having a cut-off gate at the bottom of the ash storage bin connecting to a measuring feeder. This feeder discharges at a controlled rate to the large inclined rotating mixing drum where water sprays are distributed. A longitudinal scraper bar is mounted the length of the drum, but is spaced ½-in. off the drum. As the drum rotates, the scraper plows the dampened ash off the inner side and causes it to mix thoroughly with the spray water. The scraper bar is so mount-

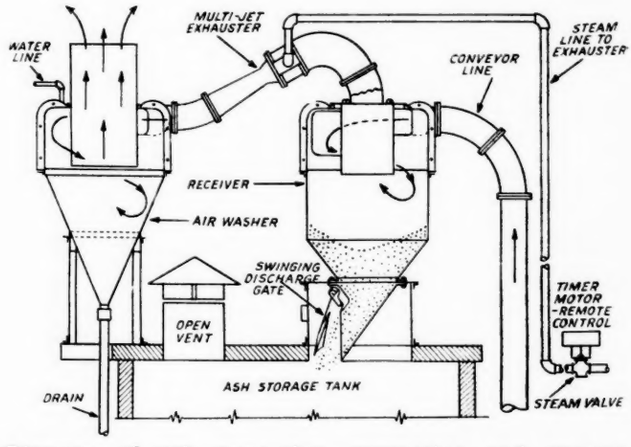


Diagram of ash conveying, separating and storage system.

ed that it swings away to let clinkers pass. The mixing process is so thorough that dust is eliminated. Dampened ashes without excess water is discharged into trucks which may be driven under the supporting structure. The trucks remove the ashes to the nearest city dump. The entire ash silo and accessory equipment are enclosed by a brick structure which blends with architecture of existing plant building.

Engineers and Equipment Suppliers

Owner and operators	Metropolitan Life Insurance Company
Engineers	Burns and Roe, Inc.
General contractors	Starrett Brothers & Eken, Inc.
Heating and mechanical equipment contractors	Baker, Smith & Company, Inc.
Electrical contractor	L. M. Comstock & Company
Water lines and drains	J. L. Murphy, Inc.
"Nuveyor" ash conveying and dustless unloading equipment	United Conveyor Corporation
Coal conveyors	Robins Conveyors, Inc.
Combustion control systems	Bailey Meter Company
Combination pulverized coal burners	Peabody Engineering Corp.
"Atrita" coal pulverizers	Riley Stoker Corporation

Convectors Used with Unit Ventilators in Schools

Where unit ventilators only have been employed for school heating, there have been complaints of uncomfortable condition existing. It has been found that the use of unit ventilators *in combination with convectors* has eliminated the cause of this discomfort, according to A. A. Maycock, of the A. A. Maycock Co., Salt Lake City, writing in a recent issue of *The Modine Salesman.*

Convectors located in outside walls provide heat to intercept down drafts of air falling down the windows.

Stratification is generally occasioned by the greater differential between temperature of fresh air introduced by unit ventilators and temperature of room air. With supplementary heat from convectors in the room, the unit ventilators have lower outlet temperatures than they would have without this supplementary heat. As the temperature of the outside air introduced approaches that of the room air, more perfect diffusion is effected and more uniform air movement is achieved. When extreme temperature differentials are involved, the tendency of a unit ventilator with vertical discharge is to more violently move the air near the ceiling with a minimum movement of air near the floor.

Better Temperature Control

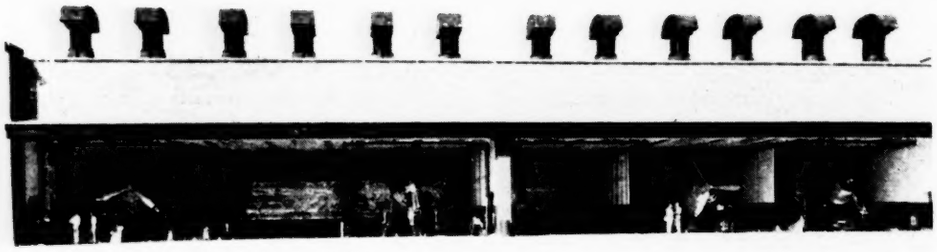
One of the pronounced advantages of employing convectors in conjunction with unit ventilators or a central blast system is the greater practicability of maintaining temperatures between heating periods in the afternoon and the following morning, and also over weekends. Heat supplied by convectors alone is adequate to maintain comfortable conditions for the janitorial services to be performed. This is possible *without the use of motors* and the additional servicing and maintenance expense involved in operation of the entire system. This heat is also sufficient to protect against freezing plumbing fixtures and pipes. It is not desirable to allow a building to completely cool off between heating periods with resultant extreme expansion and contraction of the structure. Furthermore, as a building absorbs considerable cold and subsequently is returned to normal temperature, an uncomfortable condition exists. The surface temperature of desks, benches, walls and other surfaces is not yet equal to room air temperature and hence absorbs, by radiation, the heat from the bodies.

In the event of electrical failure interrupting operation of unit ventilators or central blowers, sufficient room temperature can be maintained (except in very severe weather) by convectors alone.

Ventilators Not Properly Operated

Regardless of local ordinances or school regulations, teachers will not operate unit ventilators, and janitors will not turn on central blast systems *for ventilation purposes only.* There is a certain natural desire to open windows and enjoy natural ventilation. As a result, it is found in practically every case that unit ventilators are not turned on unless heat is required of them. In mild weather convectors supply adequate heat; windows are used for ventilation and unit ventilators are not operated. As previously stated, this will be experienced regardless of rules and regulations. The writer sees no disadvantages in it from a practical standpoint.

Non-ferrous convectors are preferred to cast iron radiation for the supplementary heat because they are quicker in heating up and much more responsive to automatic control. When desired room temperature is reached and the automatic valve cuts off the convector, there is little residual heat in the mass to cause a continued build-up of room temperature. Pupils adjacent to the convector are not uncomfortable or drowsy as the heat is convected. They do not have the concentrated radiation effect on them that is generally experienced where cast iron type radiation is used.



Building can be used as two separate booths for completely assembled bombers with wings extended, or by means of partitions. each booth can house three fighter planes with wings folded. The two booths are 160 ft. long, 60 ft. deep and have a clear height of 20 ft. Hoods on roof contain input fans.

Washwater spray booths for

Painting Airplanes and Parts

P. J. WILSON
Sales Engineer, L. J. Wing Manufacturing Co., New York, N. Y.

ONE of the many problems solved by the aircraft industry within the last few years has been spray painting. Up until 1938 or 1939, the painting of airplanes and airplane parts was not considered difficult. It was done in the factory wherever convenient, or even out in the yards, weather permitting. However, mass production of military combat planes changed all this.

When it became necessary to deliver airplanes at a fixed daily rate, rather than one every week or so, the problem of painting became a major one.

The obvious attempt to draw on the experience of the automotive industry was not very satisfactory mainly because of the vast difference in manufacturing methods, and the size and shape of the final product. In the automotive industry where dipping is used very extensively on a uniform size product produced on the conveyor system, the matter of finishing, usually with lacquer, had been worked out to a nicety.

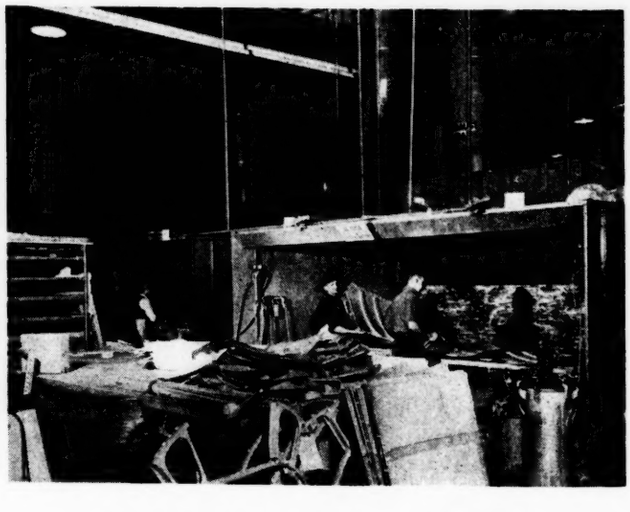
In most cases, airplane parts have to receive a protective coating before assembly, and then the final large bulky object finished as a complete unit. These methods necessitate the finished spraying of innumerable small, large and odd shaped pieces of sheet metal, in many cases chemically treated first.

Small paint shops were set up using the dry baffle method of exhaust to carry off the over-spray. This exhaust was so inadequate in most cases, that it was necessary to supply spray gun operators with respirators. This type of operation, especially on ships for the Navy where a zinc chromate primer was required, was entirely unsatisfactory. Anyone who visited an aircraft factory employing these early production methods has a very vivid recollection of yellowish green deposits all over the outside of the buildings, and in many cases, on cars in the parking field. This over-spray accumulation presented a very serious fire hazard both in the exhaust stacks leading from these paint rooms, and in its accumulation on the roofs of buildings. Plant fires occurred at some of these locations. Flames spread rapidly when fanned by high velocity air streams from the paint booths.

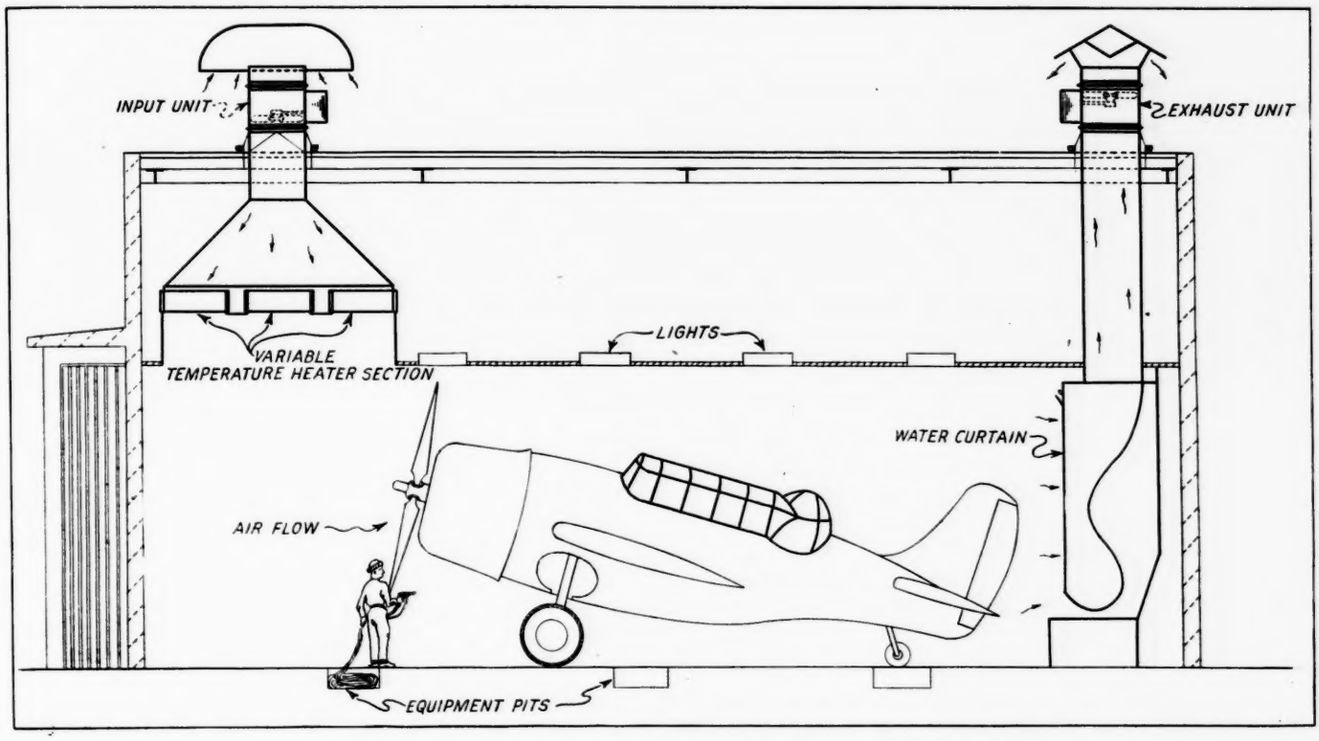
The water wash type of spray booth in which the contaminated air containing the over-spray is thoroughly washed with water before being exhausted to the outside, was then adopted. This type of spray booth, while not new to the more experienced manufacturer using spray painting, presented many new problems.

Most water wash spray booths until then had been used for coating small uniform size parts in very confined areas, and as a rule, not under twenty-four hours a day production methods.

Many methods had been tried for the construction of these water washed spray booths. In some booths, the air is moved vertically either up or down, while in others it is moved horizontally from an opening through a water wash curtain. Both methods have advantages. However, present practice seems to favor the horizontal air movement.



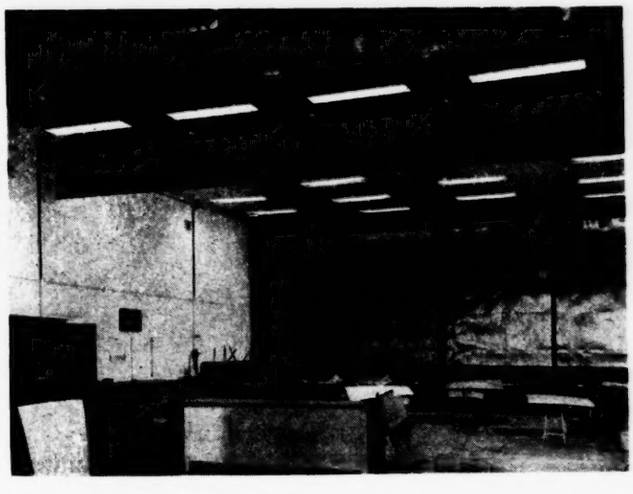
Spray booth for painting small parts.



Cross section of water wash paint spray booth at airplane plant.

Spray booths of different shapes and sizes have been built to meet requirements of the aircraft industry. For instance, a booth to accommodate a completely assembled airplane, wings and all, must of necessity be high and at the same time not too narrow. An interior booth height of at least 15 ft is not at all uncommon, and in many cases greater heights have been necessary. Such large booths necessitate the handling of enormous quantities of air. As a rule, they have been very satisfactory in operation, for a large volume of air is used which will then contain a comparatively small amount of over-spray.

The opposite of this condition exists when the small parts paint booths are considered. It must be remembered that the object of the design of the booth is to keep the face area as small as possible to reduce the amount of air required. A parts paint booth is usually limited in height to 7 ft to accommodate the average operator. Many small and odd shaped pieces as well as large flat sheets are finished in these booths. All can be handled in and out of the booth very quickly, permitting a very rapid and concentrated spraying within the area. This produces a high ratio of over-spray to air exhausted, making the washing problem very difficult, especially with the Navy specification of zinc chromate as a primer.



Paint spray booth showing the variable temperature heating sections at the top and the water curtain at the back of the booth. Note the fluorescent lighting fixtures.

Air handling equipment manufacturers have kept up with these changing conditions and are able to supply the necessary type of axial flow fan equipment to meet requirements of both exhaust and input systems.

The input air, which at one time was never considered much of a problem, gets to be quite a job when quantities in hundreds of thousands of cfm are encountered. This input air must be heated. Some idea of this problem can be gained from the fact that in the average aircraft factory of today, about 75% of the steam generated is used to heat the air exhausted by the paint shops and chemical equipment requiring fume exhaust; the remaining 25% is used for the comfort heating of the building.

The installation on the top of the building illustrated has 12 fans supplying the 400,000 cfm needed by the exhaust equipment. Each fan is, in turn, connected to three automatically controlled heating sections designed to deliver the proper temperature of air to this room at all times. Openings in the

ceiling are for the fluorescent lights, which are mounted above the paint shop out of the explosive area. Light passes through wired glass into the paint shop, giving a complete daylight effect throughout the shop.

Fresh air supplied to the water washed spray booths amounts to 400,000 cfm per minute. Twelve Wing straight-line belt-driven fans deliver this air into the booth through 12 banks of three Wing variable temperature heating sections. Each heater section is equipped with by-pass dampers automatically controlled by an air-stream thermostat; fresh air at exactly the right temperature is delivered into the booth regardless of outdoor temperature conditions and without the throttling of the steam supply. Full steam pressure is carefully maintained at all times.

Fresh air supply units are located on the roof of the building near the front of the booth. An installation of 12 exhausters at the rear end of the booth draws the exhaust air with the contained overspray through the contained water wall.

The exhaust fans from this paint shop require 150 hp of electricity (1 kw = 1.34 hp); the input fans, 120 hp; the pumps to recirculate the water for the water wash curtain, 45 hp. To heat the building on a zero day requires 1,200 boiler hp. This steam is consumed by the inlet for the fresh air having a face area of 392 sq ft of extended surface steam coil.

Respirators are not used and the over-spray is so completely removed that the walls and floors are clean at all times. All the equipment, both heating input and exhaust, was designed, built and installed by one manufacturer.

Refrigeration for Army in India

Somewhere in India, men of Quartermaster Refrigeration detachments can be seen loading meats, eggs, butter and other perishable supplies into strange trucks that look like misplaced airplane crates.

Careful inspection of the peculiar contraptions reveals that they are refrigeration trucks used to transport foods which require protection against the heat of summer in the Far East to American troops stationed in the area. Still closer inspection reveals that the original impression was correct. They *are* airplane crates, cleverly bolted to the chassis of a flat truck, and insulated with cork to keep the hot air out and the cold air in.

Refrigeration is a major problem in a land such as India, where there are few facilities for the protection of perishable foods and the manufacture of ice. When the necessity for supplying more adequate facilities for cold storage and ice manufacture became apparent, Army authorities looked around for a solution. There were no Quartermaster Refrigeration companies in the theater, and they are the only units in the Army having specialists who are trained for this sort of a job. However, the ice had to be made and the cold storage facilities were necessary to protect the health of the American troops. In one area a detachment was formed, personnel being made up of men who had enough mechanical ability to tackle a job such as ice-making. An antiquated ice plant was turned over to them, and they were told to get to work.

First problem to be tackled was that of the refrigeration trucks. It was useless to store foods overnight in cold storage if they would spoil while being delivered the next day. Several flat trucks were available. A member of the detachment spied some unused airplane crates which were just the right size for mounting on the trucks' chassis. The insides of the crates were lined with cork, then they were bolted to the truck frames, and the detachment found that it had devised a fine refrigeration truck.

An ingenious device was installed so that these trucks could be cooled by drawing air from the cold storage rooms of the ice plant. Several of them were built, and plans were shipped to other theaters of operations so that they could utilize material which was likely to be at hand for the manufacture of their own refrigeration trucks.

The next problem to be met was the plant itself. No ice was being turned out, and ice for the cold storage rooms had to be procured from an already overworked local ice company. By the time the repairs had been completed and improvements made, what amounted to an almost complete rebuilding job had been done by the detachment.

Many of the coils in the rooms were useless and had to be replaced with banks of new coils which were built on the spot. False wooden ceilings were installed to cut down the amount of air space which had to be cooled in the cold storage rooms. All of the ceilings and some of the walls had to be lined with cork insulation. Air tight doors had to be built and installed. A loading platform was put in, and a roadway built leading up to the platform. New water cooling towers were constructed. All the Diesels had to be overhauled, and in many cases new parts had to be installed before they would operate. The entire plant had to be painted and lavatories and showers installed.

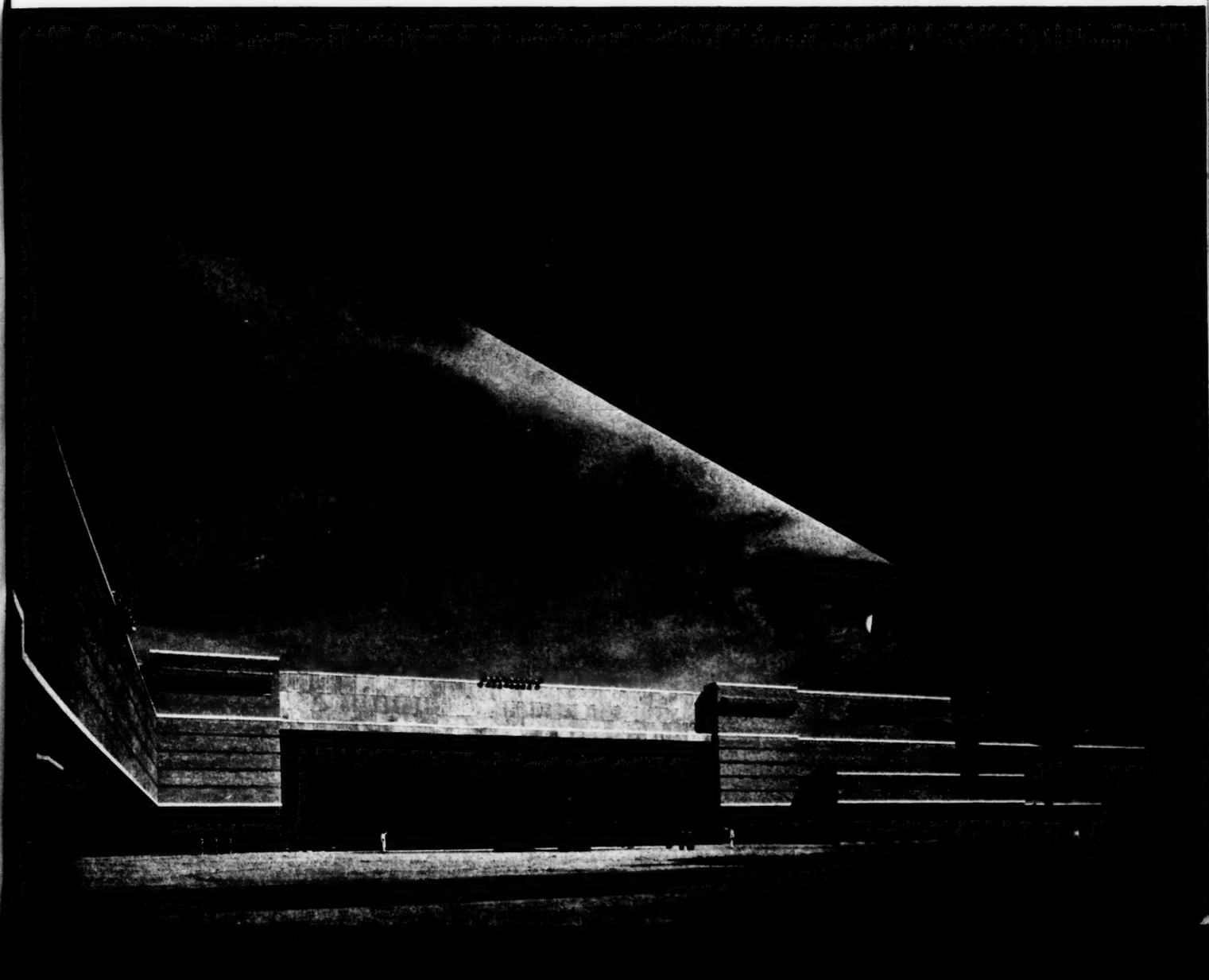
Today this plant is producing all the ice needed by the American troops stationed in that area. Cold storage rooms are in operation storing beef, ham, butter, chicken, eggs, fowl; in fact, all the perishables which the American troops use.

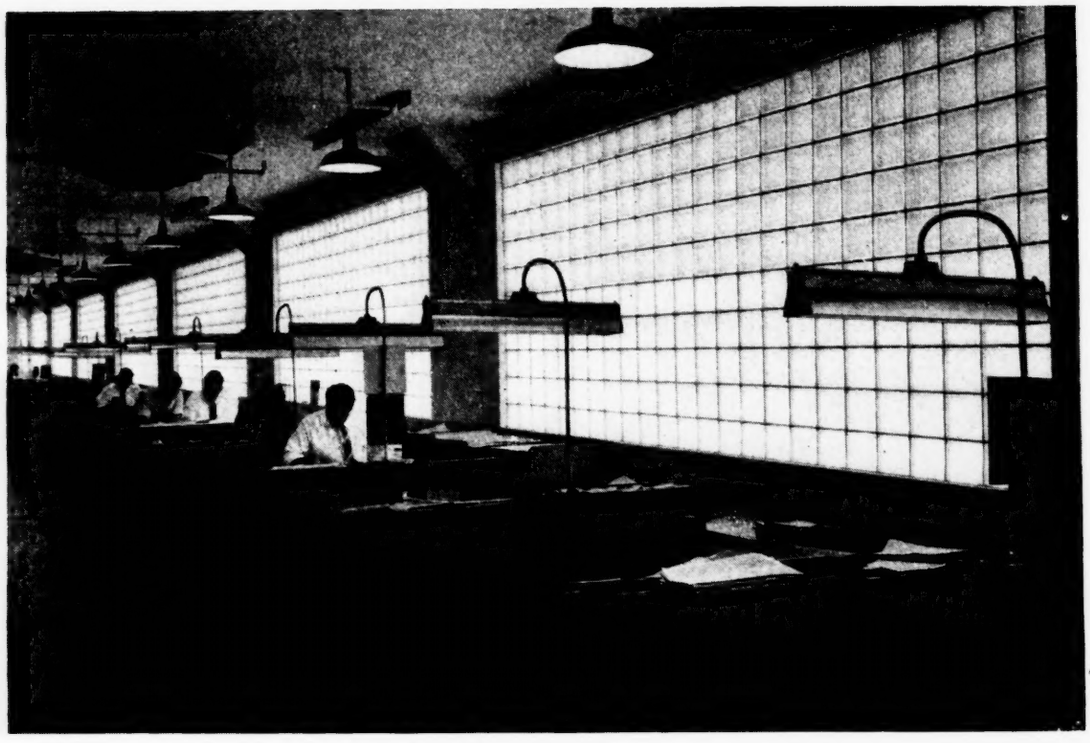
An electrically-operated ice cream freezer is now turning out this favorite American delicacy. Once again it was necessary to improvise and build the freezer from materials at hand. Mix for the ice cream is made at the plant in a kitchen which was installed by the Army.

PROFITS IN AIR

HOW INDUSTRIAL PLANTS PROMOTE PROCESSES BY CONTROL OF AIR CONDITIONS

Douglas C-47 Skytrains are coming off the line at this windowless plant designed by The Austin Company for the U. S. Army Engineers. There are seventeen million common brick in the plant's "breathing" windowless walls. Completely air-conditioned, outside air is taken in through louvers like those seen on either side of the telescoping door. Photo courtesy The Austin Company.





Good lighting, provided by light-directional glass blocks, plus complete air conditioning, furnishes ideal working conditions for this fifth floor engineering department in the new Kollsman building.

Kollsman Instrument Division

PROFITS IN AIR
HOW INDUSTRIAL PLANTS PROMOTE PROCESSES BY CONTROL OF AIR CONDITIONS

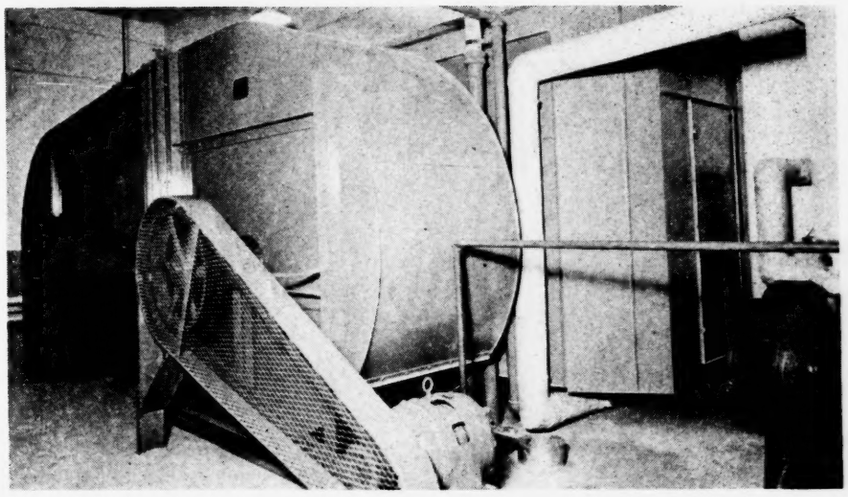
of Square D Company in its precision instrument manufacture uses complete air conditioning system for final assembly operations, blackout ventilation for all other departments.

THE new five-story manufacturing building recently completed as a Defense Plant Corporation project for the Kollsman Instrument Division of the Square D Company at Elmhurst, N. Y., is another good example of the speed which has characterized the program of war plant construction so intensively engaged in by the nation since Pearl Harbor. At the same time, it illustrates how well-planned and efficiently executed such construction can be even under the stress of an emergency such as has existed during this period.

Rectangular in plan, of reinforced concrete construction, the new building required only ten weeks from breaking of the ground to the complete enclosing of its many thousands of square feet of floor space, and a total of seven months to full operation of the plant.

While censorship restrictions covering manufacturing operations permit saying only that precision instruments are produced here, it is permissible to describe the air conditioning system and the heating and ventilating systems which are important to the manufacturing processes because they provide the proper working atmospheres necessary for the exacting operations employed.

The complete air conditioning system which serves the top, or fifth, floor is described later. It is on this floor that the delicate instruments are assembled and given final tests, and here the close control of temperature and humidity play a vital part in maintaining the small tolerances which the products require. This floor is encircled by an almost continuous band of light-directional glass blocks, which provide not only efficient and comfortable lighting but also, due to their relatively low heat conductivity, permit the carrying of the necessary rather high de-



This Buffalo Forge blower located in the penthouse provides filtered outside air for ventilating one-half of each of the four lower floors of the new building. A similar fan in the opposite end of the penthouse ventilates the other half.

gree of humidity without condensation during cold weather, and lighten the load on the cooling system in the summer.

Blackout Ventilation

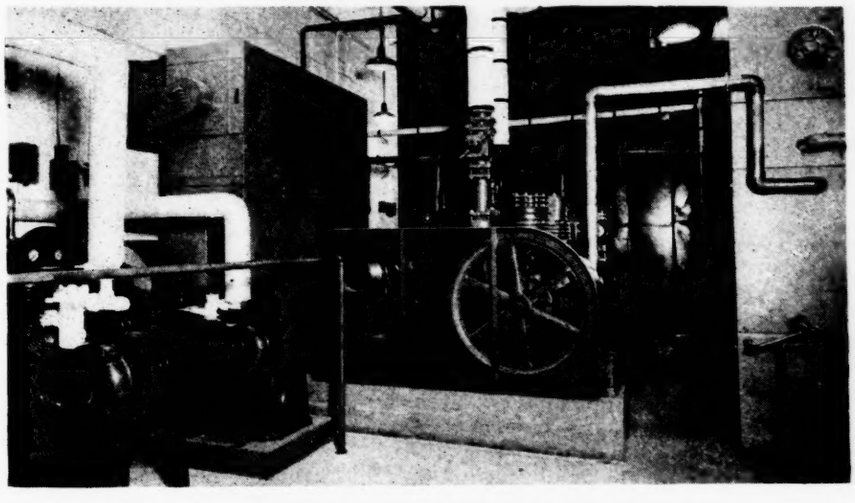
The other four floors have steel sash and clear glass windows and, while not completely conditioned like the fifth floor, do have a central ventilating system intended for the furnishing of clean fresh air during the summer months, and especially during blackouts. The heat liberated from motors, from process work and from personnel is such that room conditions soon would become unbearable during warm weather with doors and windows closed and drapes drawn to completely black out the plant. While opening the windows during non-blackout periods would partly answer this problem, it introduces another, the problem of dirt. The ventilating system will bring in sufficient fresh air to create an outflow at all such openings and is expected effectively to prevent the entrance of dust into the working areas.

Two duplicate groups of equipment, located in the roof penthouse along with the complete conditioning equipment serving the top floor, provide this change of air. Each group serves one side of each of the first four floors through a longitudinal duct, these ducts extending alonside a central utility section and discharging the air outwardly, through grilles, toward the windows. This central utility section includes elevator shafts, stair wells, locker rooms, and wash rooms for men and women, and housed in it also are two 30 sq ft masonry shafts which bring the fresh air from the penthouse down to the longitudinal ducts on each floor.

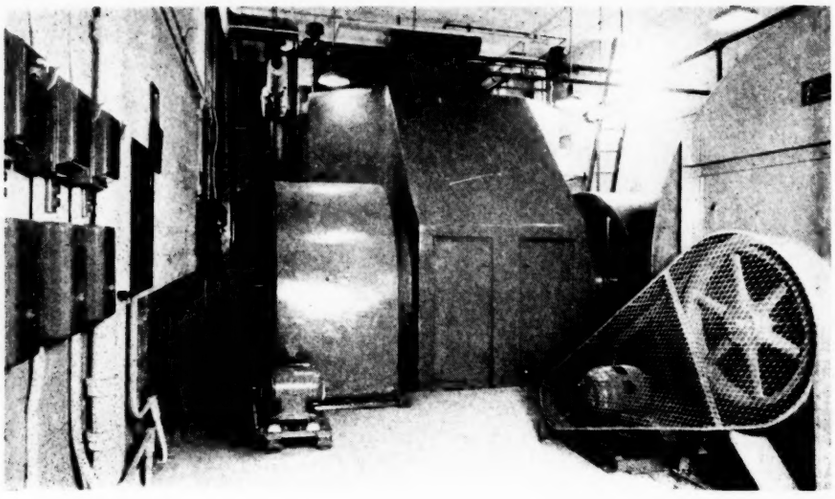
The penthouse equipment consists of louvred openings in the penthouse walls, spun glass filters, and belt-driven blowers discharging vertically downward into the square masonry shafts mentioned. Heaters, it will be noted, are not included in this equipment, since the system will not be used in cold weather. In fact, it will be used only in warm or fairly mild weather, when the capacity of the building heating system, aided by the heat liberated from machinery and employees, is sufficient to offset the cooling effect of the fresh air brought in from the outside.

Building Heat

The heating of the first four floors is taken care of by a combination of hot water convectors, located



Duplicate refrigeration equipment, each group composed of a 40 hp reciprocating compressor with evaporative condenser, receiver and evaporator, serves the air conditioning system. Interconnection of the compressor liquid and suction lines, and the use of by-passes, permits emergency operation on one group, if desired.



The divided system also characterizes the air handling equipment for the conditioned fifth floor. There are two supply fans, two spray-type humidifiers and dehumidifiers, and two sets of reheating coils, only the mixing chamber being common to both systems.

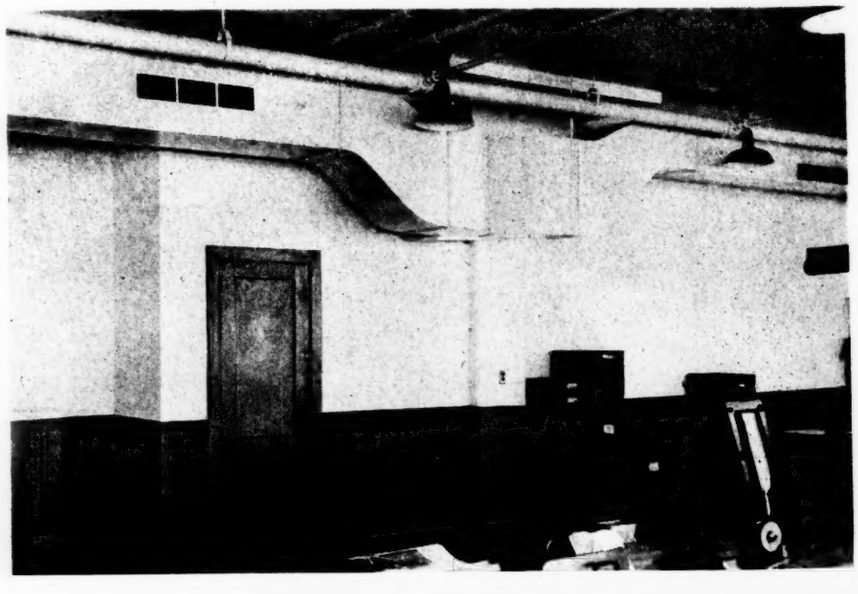
beneath the windows, and hot water unit heaters suspended in bays midway between the walls and the central utility section. The unit heaters are automatically controlled by ceiling thermostats, and their capacity is such that only a fraction of the total room heat requirements are supplied by them. Most of the heat load is handled by the wall radiation, with water temperature centrally controlled to keep the heat emission from these convectors somewhat below the room requirements, so that the balance will be supplied automatically by the unit heaters.

An effective ventilation system is used in the radium painting department where dials and hands of the various instruments are coated to render them self luminous. This once hazardous operation is performed in comparative safety by the use of small glass-enclosed booths from which positive exhaust is maintained by a central ventilating system, with a duct connection to each booth. A small slot permits only the hands of the operator to be in the booth, with all paints and brushes kept inside the booths, and the work performed by observation through the glass.

Fifth Floor

The air conditioning system for the fifth floor[1] of the new building was installed to provide constant temperature and humidity in those parts of the building where precision instruments are assembled and tested. Temperature and humidity are kept constant although a certain range of variation is permissible. In winter time the dry bulb temperature is maintained at 72F with 1½F fluctuation, positive and negative, and in summer at 75F with the same margin of variation. The relative humidity is kept at 50% all year round with a variation of ± 5%. These conditions are maintained with an internal load of several hundred people, 3,000 watts of electric light, 50 hp connected load, and 5,000 cfm of outside air. A reduction of the normal cooling load of the building has been effected by supplying roof insulation and glass bricks in place of standard windows around the perimeter of the building.

[1]The text describing the air conditioned fifth floor was prepared by Peter Franck, Mechanical Engineer, Tiltz Air Conditioning Corp., New York City, designers and installers of this portion of the building equipment.



Ventilating air, brought down from the penthouse fans through square masonry shafts in a central utility section of the building, branches through these typical distributing ducts to serve the first four floors. A definite pressure is created in the rooms, causing an outflow of air at all window cracks or other openings, thus preventing entrance of dust.

Capacity

With these internal loads and the customary maximum outdoor conditions of New York City (95F dry bulb and 75F wet bulb) the cooling load of the fifth floor was calculated to be 89 tons of refrigeration. The heating load was split up between the portion that is taken care of by standing radiation along the walls below the glass brick openings and the portion supplied by the central air-conditioning plant. The standing radiation was calculated to maintain a minimum temperature of 50F at all times. The air conditioning system supplies additional 350,000 Btu which are necessary to maintain the 72F temperature level. Sufficient heat from the central boiler plant is also provided to permit reheating in summer time for humidity control.

Air Distribution

The arrangement of the internal columns, the central utility section and the outside walls of the building is such as to create numerous bays, each 20 ft square. It was originally considered that proper air distribution should be obtained by the use of ceiling outlets in the center of each bay, thus requiring 44 ceiling outlets with the necessary branch ducts to the outlets. Later on, in order to simplify the duct lay-out and also to reduce the number of air outlets it was decided to locate the return air registers in the utility section so as to draw the air from the outside bays of the building across an area which did not have any supply outlets. By this short-cut, eight supply outlets and their corresponding branch connections were eliminated.

The air conditioning system was split into two halves with separate air handling equipment and separate distribution systems. This arrangement constitutes a compromise between complete zoning, permitting variation with the travel of the sun, and a central system. The dividing line between the two systems runs exactly east and west so that one system takes care of the south side of the building and the other of the north side. It was believed that further zoning was not called for on account of the unobstructed expanse of the floor.

Apparatus

The air handling equipment as well as the refrigerating machinery are characterized by the divided system. There are two supply fans, two spray-type humidifiers and dehumidifiers, and two sets of reheating coils. Only the mixing chamber which is supplied with the return air from below and the fresh air from above and the filter bank are common to the two systems.

Each dehumidifier consists of a set of coil-type evaporators, whose refrigerant flow is automatically controlled by individual expansion valves, and a bank of centrifugal spray nozzles. Water is circulated through the nozzles by a water pump operating continuously during the summer season to assure a wet surface on the evaporators. In the winter time—when the washer is the means of humidification—the operation of the pump is automatically controlled by the humidity requirements of the conditioned space. In addition, each circulation system is equipped with a heat interchanger which permits heating the circulating water to provide a faster rate of evaporation.

The refrigerating cycle is also part of the divided system: there are two complete cycles with 40 hp. compressors, evaporative condensers, receivers and evaporators. However, in order to provide emergency service in case of a break-down a system of by-pass connections was provided interconnecting the two liquid lines and the two suction lines. Thus the operator can close down one compressor with its evaporative condenser and receiver for repairs while the other unit is providing refrigeration either for the two systems or for either one singly. The arrangements represents a compromise between a regular standby (which would have required twice as much tonnage) and the customary parallel hook-up. The simplicity of the device is remarkable as three valves and one pipe-connection for liquid and suction lines provide considerable additional flexibility in operation.

Control

Naturally, the divided system is also carried out in the automatic temperature control system. Common to the two systems is only the fresh air control. A minimum of 5,000 cfm outside air is admitted as soon as one of the two systems is started (through a relay arrangement in the fan circuits); additional outside air is used if both dry bulb and relative humidity of the out-of-doors are such as to make the use of additional outside air economical. The additional air supply is compensated for by two relief ducts which directly connect the return air grilles with the outside. These relief ducts are equipped with automatic dampers operating in conjunction with the maximum outside air damper.

On each half of the system temperature control is provided by the controlling room thermostat with a low limit control in the fan supply duct. The room thermostat provides heat by opening the hot water valves feeding the reheating coils. It also regulates cooling by operating the compressor and its 50% capacity reduction mechanism. The room humidistat similarly provides humidification in winter time in two steps by first operating the circulating pump of the spray humidifier and then, upon a further demand for humidification, opening the water valve admitting hot water to the heat interchanger which raises the temperature of the spray water. It also controls dehumidification in summer by operating the compressor and its capacity reducing by-pass for dehumidification. If the compressor thus operates for the purpose of dehumidification the low limit control as well as the room thermostat will operate to maintain constant temperature in the conditioned space by means of reheat.

Law on Heating Contracts

By LEO T. PARKER

Attorney at Law, Cincinnati, Ohio

A GREAT majority of law suits involving heating and ventilating contractors results from disagreements and misunderstanding of installation contracts. It is admitted by legal authorities that the average contractor who has elementary legal knowledge may eliminate almost all litigations involving contracts. This is true because no one who believes that an adverse verdict is likely will start a suit, whereas if it is apparent that a favorable verdict is logically certain, then the other party to the litigation may readily be induced to compromise. This is particularly so if his attention is directed to late and leading higher court decisions which clearly indicate the legal status of the parties.

Therefore, it is advisable, as well as being a matter of interest, for heating and ventilating contractors to read brief digests of suits involving others in the industry. Moreover keeping a record of higher court cases, referred to in these pages, is a simple method of avoiding a great deal of expense, loss of time and wasted effort.

Fundamental Principles

First, it is important to know that the higher courts are in accord with the principle of law that a property owner who breaches a contract *always* is liable to the contractor for damages. Moreover, a breach on the part of an owner is *any* act not in accordance, expressed or implied, with the contract.

This point of the law is well illustrated by the outcome of the leading case of Wickliffe vs Cooper & Sperier, 120 So. 52. The facts of this case are that a contractor entered into a contract with an owner to remodel an old apartment building. The contract provided that the work should be done in strict accordance with the plans and specifications which were made part of the contract. The only provisions that the specifications contained relative to heating were the reference, under the heading of "Plumbing," reading, "Plumbing, see heating," and under the heading, "Gas Fittings," the following: "Heating to be furnished by owner and installed by contractor."

After the building was partly completed the owner contended that the contractor should install a special heating system. The contractor explained to the owner that in this remodeling job it was impractical to install the pipes for the system selected by the owner. In fact its installation would have necessitated making expensive changes in the partly constructed building.

The owner then cancelled the contract and sued the contractor for damages. However, the court promptly held the owner liable in full damages to the contractor.

The important points exemplified in this decision, as explained by the court, were that an owner breaches an installation contract when he (1) fails to conform with the terms of the contract; (2) attempts to compel the contractor to make changes not agreed upon; or (3) demands that the contractor perform work ordinarily impossible.

Efficient System Required

Various higher courts have held that a contractor who agrees to install new heating equipment which shall operate in conjunction with an old system is required to complete his work so that both the old and new systems operate together satisfactorily.

For instance, in Vane vs Stanley Heating Co., 152 Atl. 511, a heating contracting firm contracted to make all necessary connections to make a complete hot water job, and install certain new radiators.

When the job was completed the owner refused payment on the ground that several of the radiators in the old system would not heat properly.

The contractor contended he was not responsible for operation of the old radiators because he had contracted only to install new radiators and connect same with the old system. It is important to know that the higher court held the contractor bound to repair the defective condition of the complete system, and said:

"It seems to us that a job which left several radiators cold could hardly be called a complete job; that a complete hot water job for that house meant making the entire plant work, the old as well as the new part, if plaintiff (contractor) assumed the responsibility of hooking up with the old works."

Therefore, in view of the law established by the higher court, it is quite apparent that all contractors should be certain that a

contract for a repair or partial installation job does not contain a clause or statement which may be implied to mean that the contractor guarantees the complete system will operate satisfactorily. In fact in contracts of this nature it is advisable to include a clause to the effect that the contractor guarantees only the equipment that he contracts to install and that he does *not* guarantee efficient operation of the old system.

Common Contract Law

The laws relating to installation contracts are well established. Therefore, generally, the outcome of a litigation may be anticipated with reasonable certainty by contractors familiar with previously decided higher court cases on the same or similar subject. Also, it is important to know that the records of the courts prove conclusively that the majority of legal controversies involving contracts should never have existed had the contracting parties been informed of the established law.

For example, a valid and enforceable installation contract is defined by modern higher courts as a transaction between two or more parties whereby eash of the persons is obligated to something definitely specified. The contract may be written, oral, expressed, or implied, so long as it complies with valid statutes and ordinances.

Generally, a verbal contract is equally as effective as a written one. However, the important difference between a written and an oral contract is that in litigations the parties must introduce verbal testimony to prove the exact contents of an oral agreement, whereas the courts construe a written contract strictly in consideration of its written contents. Moreover, *side* or verbal agreements have absolutely no effect to vary the legal obligations in a written contract.

For example, in Pleasant vs Arizona Distributing Co., 267 Pac. 794, it was disclosed that a contractor entered into a written installation contract. The contractor refused to fulfill the terms of the contract and the owners sued to recover damages. The contractor defended the suit on the ground that in addition to the written contract a verbal contract had been made by which it was mutually agreed that he should be paid for his work daily, depending upon the number of men he had on the job. The contractor also contended that the owner had breached this agreement by failure to pay for the work on a daily basis.

In holding the contractor bound by the written contract, the court explained the law as follows: "This court has repeatedly and consistently held that all contemporaneous and prior conversations and agreements and negotiations in regard to the terms of contracts finally reduced to writing are merged in the written contract and by it supplanted, and are thereafter immaterial and inadmissible in evidence to vary the terms of a written contract."

Law of Guarantees

It is well established law that contractors are bound to fulfill the exact terms of a guarantee. Also, it is well to keep in mind that in many states laws have been passed which require owners to file suit on a breached warranty within a specified period of time. Therefore, it is important to know that the date such suit on a breached contract is required to be filed by the owner is computed from the time the owner finally determines that the work is defective and not the date the guarantee was issued. Knowledge of this law will save contractors time, effort and expense.

For instance, in the late case of White Plumbing and Heating Company, 156 S. E. 920, it was shown that a contractor entered into an agreement with an owner of an apartment building by the terms of which the former was to install a heating and ventilating plant in a new apartment building, according to attached plans and specifications, for the sum of $1760.

Four years later the apartment building owner filed suit against the contractor to recover damages alleging that the heating plant was insufficient in capacity to comply with the guarantee issued by the contractor. The apartment building owner introduced proof showing that his contentions were well founded, but the contractor attempted to avoid liability because the owner had failed to file suit in compliance with a state law which provides that suits on warranties must be filed within three years.

The owner of the building contended that he had filed the suit within three years from the date when he finally *determined* that the heating plant did not comply with the guarantee, and that this was sufficient to entitle him to a favorable judgment.

It is interesting to observe that the court held the contractor liable in damages on the breached warranty, and that the three year limitation statute started to run from the date the owner discovered, by the application of ordinary care, that the heating system was not equal to the contractor's guarantee.

Recording Contracts

On the other hand, it is important to know that when a seller of plumbing or heating equipment enters into a valid conditional contract of sale, by the terms of which he retains legal title to the equipment until the same is paid for, he should be certain to properly record the contract. If he does so he may recover possession of the equipment from a subsequent purchaser of the property, even though the latter is not informed that the conditional contract of sale exists between the original owner of the property and the seller of the equipment.

For example, in Colonial Hill Co. vs. Moncrief Furnace Co., 158 S. E. 343, it was shown that the contractor who installed a furnace entered into a contract with the owner of a building by the terms

of which the contractor retained the right to remove the furnace from the building if the purchaser failed to make the agreed payments. A short time after the installation the owner sold the building. Later when the contractor failed to receive the agreed payments he investigated and learned that the original owner had sold the building. The contractor filed suit to recover possession of the furnace.

In holding the contractor entitled to take possession of the furnace, or recover from the purchaser of the property the balance due on the furnace, the court said: "It is well established that, as between the original seller and the original purchaser, the agreed price as stated in the contract of sale is prima facie, but not conclusive, evidence of the actual value of the property ... However, in our opinion the undisputed circumstantial evidence authorized the trial judge to find that the value of the property was the amount of its purchase price as agreed on by the original seller and the original purchaser."

What are Legal Fixtures?

As above indicated valid provisions in a conditional contract of sale are enforceable between the contractor and the original owner of the building, and also between the contractor and a subsequent purchaser, if the contract is recorded. However, although the contractor may compel the last purchaser of the building to pay the balance due he may not under certain circumstances remove the equipment from the building.

For example, a person who sells an appliance, and installs it in a building may make a valid agreement with respect to the purchaser of the appliance which entitles the seller to remove the subject of the sale if the buyer refuses to pay for it. However, if the thing sold is a legal *fixture* and a third person holds a mortgage on the building, or later purchases the real property, he may prevent removal of the fixture from the building, irrespective of the agreement between the purchaser and the seller of the appliance. On the other hand, if the thing sold is *not* a legal fixture but a chattel, no one can prevent the seller from removing it from the building if the purchaser breaches the condition of the properly recorded contract of sale.

For illustration, in Madfes vs. Beverly Corporation, 166 N. E. 787, it was disclosed that a company sold to the owner of an apartment building several stoves under an agreement which entitled the seller to remove the stoves from the building if the owner of the apartment failed to meet the agreed payments therefor. Each range was attached by a simple coupling to the gas service pipe which delivered gas to the various apartments. Thereafter the owner of the apartment executed and delivered a mortgage upon the apartment houses.

When the owner of the apartment failed to pay for the stoves, in accordance with the terms of the agreement, the company attempted to remove them from the house and the mortgagor filed legal proceedings to prevent the removal on the contention that the stoves were *legal fixtures*. However, the court held the stoves not legal fixtures and permitted the company to remove them from the building, stating the following important law:

"Certain chattels have such a determinate character as movables that they remain personal property, after their annexation to real estate, independently of any agreement between the owner of the chattels and the owner of the realty which so provides ... Other chattels, notwithstanding an agreement to the contrary, conclusively become real estate after annexation thereto ... where the property could not be removed without practically destroying it, or where it or part of it, is essential to the support of that to which it is attached. These ranges were not so *attached* to the building that, as matter of law, they became part of it."

Another important point of law is that modern courts hold that if equipment cannot be removed without effecting substantial damage to the building, it is legally a fixture. Obviously, the expression *substantial damage* cannot be clearly defined. Therefore, in a majority of legal controversies involving fixtures, it is necessary that the litigants submit testimony from which the court may decide whether removal of the equipment or accessory in litigation actually will effect substantial damage to the building.

If the equipment is a legal fixture and the court failed to record the conditional contract, a new purchaser of the building, or a new mortgagee, may prevent the contractor from removing it from the building and also he may refuse to pay the contractor the balance due. Of course, proof that the new purchaser, or mortgagee, knew that the conditional contract existed, or that the owner owed money to the contractor, has the same legal weight as where the contractor actually recorded the contract.

Validity of Contracts

Still another important point of law is that where the testimony proves that the contractor recorded the contract, it is valid in all jurisdictions. In other words, the fact that a conditional contract is properly and legally recorded in any one county results in its validity in all other counties in the State, and in all States in the United States. And the law presumes that all persons in the United States have knowledge that the contract is recorded. This same rule of law is applicable to mortgages and other forms of liens.

HEATING AND VENTILATING'S *Reference Section*

LIQUID-VAPOR HEAT EXCHANGERS

By WILLIAM PARKERSON, Central Power and Light Co., Victoria, Texas

A STUDY OF THE DESIRABILITY OF

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Almost every air-conditioning engineer has, at some time or other in his career, either installed or at least considered the installation of a liquid-vapor heat-exchanger. The benefits of these devices appear to be widely recognized, in a general way; however, while many who have installed heat-exchangers, either factory-built or job-made, have undoubtedly wondered about the actual quantitative advantage thus secured, few have had time to reason out the thermodynamic relations involved. Moreover, a study of the literature on the subject would be of doubtful assistance due to the discordant opinions among authorities in the field. For example, Goodman (Trane Air Conditioning Manual) is of the opinion that the theoretical gain in refrigerating capacity is negligible; Carrier, Cherne, and Grant (Modern Air Conditioning, Heating and Ventilating) promise a 7% increase in capacity for a wide selection of easily attainable conditions; Knaus* states that "there would be little gain in economy of operation," while Newcum† proclaims "the net result is an average overall capacity increase of 15%." Where, then exactly is the truth? What IS the actual quantitative advantage of a liquid-vapor heat-exchanger? The accompanying analysis is the author's answer to these questions.

When liquid refrigerant has passed through the expansion valve orifice it finds itself in a region of very much reduced pressure. That is to say, the liquid enters a region where the pressure is far below its equilibrium pressure; or we may say that the liquid suddenly finds itself at a temperature far above its equilibrium temperature at the new pressure. Any liquid which finds itself above its equilibrium temperature will boil violently until equilibrium conditions have again been established. Equilibrium will obtain when the liquid will have surrendered sufficient latent heat in vaporizing a part of itself, to have lowered the temperature of the remaining liquid to its equilibrium temperature. Thus "flash gas," so called, is created in the expansion valve and between the expansion valve and the evaporator. In this process, a certain amount of liquid is converted into vapor without accomplishing any useful refrigeration. This is called the *expansion valve loss.*

Obviously, if, by external means, the liquid approaching the expansion valve could be sub-cooled to the suction temperature, which is the equilibrium temperature beyond the expansion valve, all of the expansion valve loss would be obviated, bringing about a very considerable improvement in refrigeration effect and a consequent decrease in the quantity of refrigerant which must be circulated to secure a given refrigerating capacity. This would be *complete* sub-cooling. Naturally, *any* sub-cooling of the liquid refrigerant approaching the expansion valve, results in the recovery of a portion of the expansion valve loss.

To illustrate how important this effect may become, Table 1 is presented.

When a liquid-vapor heat-exchanger is employed to sub-cool the liquid, a detrimental effect, growing out of the superheating of the suction vapor, tends to off-set the beneficial sub-cooling effect just described. A hypothetical compressor with an invariable displacement will circulate a smaller weight of this superheated vapor than of saturated vapor in inverse proportion to their respective specific volumes. This is the detrimental effect.

However, when the liquid refrigerant entering the expansion valve is sub-cooled by the heat exchanger the overall refrigeration effect is increased. For a given tonnage of refrigeration, the necessary weight of refrigerant to be circulated is inversely proportional to the refrigeration effect. Conversely, other things being equal, the capacity of a hypothetical compressor with an invariable displacement, will be directly proportional to the refrigeration effect. This is the beneficial effect.

The problem, then, is to calculate, analyze, and interpret the net result of these opposed effects acting simultaneously.

It is the purpose of this study to:

1. Determine the net gain in capacity resulting from use of a heat-exchanger;
2. Present data for the practical design of a job-made heat-exchanger;
3. Calculate the necessary size of heat-exchanger of the adopted design to accomplish the determined net gain in capacity; and
4. To gather the assembled information into a comprehensive set of charts for easy use in the design and application of double-pipe counter-flow liquid-vapor heat-exchangers.

Net Gain in Capacity

The method employed for determining the net gain in refrigerating capacity resulting from a liquid-vapor heat-exchanger is that of a step-by-step analysis of the pertinent data. This is accomplished in the first thirteen items in Table 4. The method of arriving at the first 13 items in Table 4 is shown in detail in Fig. 1 for one condition—a condensing temperature of 105F and a suction gas saturation temperature of 40F. (Items 14 to 21 will be referred to later.) Tables 2 and 3 are used in the calculations.

It is assumed throughout this discussion that liquid leaves the condenser and vapor leaves the evaporator at equilibrium conditions. In other words, the liquid leaving the condenser is neither sub-cooled, nor possessed of any flash gas; the vapor leaving the evaporator is dry and saturated. Moreover, the effect of pressure changes due to kinetic friction in the heat-exchanger are neglected. By scrutinizing, individually, the steps shown in Fig. 1 and the first 13 items in Table 4 in the order in which they occur, one may

*Heat Interchangers in Commercial Refrigeration, by W. L. Knaus; *Refrigerating Engineering*, July, 1937, page 21.

†The Application of Heat Exchangers, by K. M. Newcum; *Refrigerating Engineering*, February, 1942, page 77.

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LIQUID-VAPOR HEAT EXCHANGERS

easily follow the line of reasoning to its logical conclusion.

From the foregoing statements, it is obvious that the superheating of the vapor gives rise to a ratio of capacities less than unity, since the capacity tends to decrease in proportion as the specific volume increases. This is illustrated in Item 6 of Table 4 and Fig. 1. On the other hand, the sub-cooling of the liquid brings about a ratio of capacities greater than unity, because the capacity tends to increase in proportion as the refrigeration effect increases. This may be seen in Table 4 and Fig. 1 under Item 12, which is simply Item 11 divided by Item 3.

The net gain in capacity is manifestly the gain minus the loss. If the "Ratio of Capacities — Sub-cooling" (105F condensing temperature, 40F saturated suction temperature) is 1.1633, the percent gain from sub-cooling will be (100 × 1.1633 — 100 =) 16.33%. And if the "Ratio of Capacities — Superheating" is .8780 (same conditions) the loss from superheating will be (100 — [100 × .8780]) = 12.20%. Thus the Net Gain will be (16.33 — 12.20) = 4.13%. The Net Gain is shown in Table 4 for six different sets of refrigerant conditions.

The figures in Table 4 were calculated on the assumption that the vapor in passing through the heat-exchanger, would be superheated to within 10F of the condensing temperature. This is the so-called Small Temperature Difference appearing as Item 15 in Table 4. Another table, in all other respects similar to Table 4 was compiled for each of the Small Temperature Differences of 1F, 5F, 20F, and 40F, respectively. These five tables supplied material for a family of six tables of which Table 9 is a sample, as will be discussed later.

From a study of the compiled information, it appears that the Net Gain, for the conditions herein considered, ranges from 9.51% (at 30F suction temperature, 115F condensing temperature and a small temperature difference of 1F) to .33% (at 50F suction temperature, 105F condensing temperature and a small temperature difference of 40F). Between these two extremes lie many practical values of 4%, 5%, and 6%, where a heat-exchanger may easily justify its existence and pay its way.

TABLE 1.—THEORETICAL MAXIMUM INCREASE IN CAPACITY POSSIBLE BY SUB-COOLING

	Condensing Temperature = 105F			Condensing Temperature = 115 F		
	Saturation Temperature of Suction Gas Leaving Evaporator, F					
	30	40	50	30	40	50
Expansion valve loss, per cent	26.39	23.44	20.35	30.13	27.24	24.23
Complete sub-cooling, Degrees Fahrenheit	75	65	55	85	75	65
Possible capacity increase with complete sub-cooling, %	35.85	30.61	25.55	43.12	37.44	31.98

Exchanger Arrangement

Thus far, no restriction has been placed as to the type of heat-exchanger employed. The foregoing is, in this respect, general and applies equally well to any design. Factory-built heat-exchangers, the products of reputable manufacturers, are available on the market. In the past few years, many of them have been installed with good results on war-plant jobs, throughout the country. Their list price ranges from $5 to $14 per ton, depending upon size. Generally speaking, they employ a coil of finned tubing as liquid line, installed on the inside of a cylindrical copper shell, through which the suction vapor passes. In cases where space limitations are of first importance and where inexperienced pipe fitters must be used, factory-built heat-exchangers take on a special interest. But now, specifically, we will discuss the job-made type—the double-pipe counter-flow liquid-vapor heat-exchanger, which may, obviously, be constructed either with the liquid line on the inside of the suction line or vice versa. In either case,

TABLE 2.—PROPERTIES OF FREON-12 AT SATURATION

Temperature	Heat Content, Btu per Lb	
	Liquid	Vapor
30F	14.75	81.61
40F	17.00	82.71
50F	19.27	83.78
105F	32.40	89.03
115F	34.90	89.80

the line to be placed on the inside would retain its original design size. The other line would have to be enlarged sufficiently so that the annular space between the two resulting lines would have an area at least as great as the internal area of the enlarged line before enlargement.

Table 6 is designed to assist in the selection of the proper size of the outer pipe, with supplementary necessary data given in Table 5. The following practical example will illustrate the use of Table 6 and, at the same time, introduce the question as to whether the liquid line should be on the inside or outside of the suction line.

Example: Suppose, in a given air-conditioning system, it be found necessary to install a 1⅛ in. O. D. liquid line and a 2⅝ in. O. D. suction line. From Table 6, the inside area of the

The author concludes that under normal refrigerant conditions economy of operation results from use of a liquid heat exchanger. However, even if the exchanger achieves no net gain in capacity, it still offers two worthwhile advantages: first, that if the exchanger is as near as possible to the condensing unit it adds to the capacity of the refrigerant lines due to the decrease in weight of refrigerant circulating; second, a heat exchanger affords dry suction gas at the compressor and allows closer adjustment of superheat to be maintained at the expansion thermo-bulb.

liquid line may be found to be .825 sq in and that of the suction line, 4.772 sq in. Now, if the liquid line is to be placed on the inside of the suction line, the shaded area at the left in Fig. 2 must be at least 4.772 sq in. Referring to Table 6, the size of the smaller liquid line is fixed at 1⅛ in. Opposite 1⅛ in the first column move horizontally to the nearest figure larger than 4.772, and find 5.818. This number appears under the 3⅛ in. column and fixes the outside pipe as 3⅛ in., and gives an annular area of 5.818 sq in.

Likewise, if the suction line is to be placed on the inside, the shaded area at the right in Fig. 2 must be at least .825 sq in. In Table 6 move opposite 2⅝ in. to 1.400 and find that 3⅛in. O. D. is the smallest outside pipe which satisfies this condition, giving a net annular area of 1.400 sq in.

Either of the two designs pictured in Fig. 2 will apparently serve the purpose equally well. Which shall be chosen?

In the first place, reference to Table 5 will show that, with the liquid line on the inside, the heat exchange surface swept by the vapor is .295 square feet per lineal foot. Compare this with the .645 square feet per foot representing the heat exchange surface swept by the vapor when the suction line is on the inside. It is obvious that the vapor will sweep more than twice as large a heat transfer surface in the second case.

Now, if the relative cost of the two alternatives is investigated, it is found that when the suction line is placed on the outside it is necessary to insulate the heat-exchanger, preferably with ice-water thickness cork. On the other hand, when the liquid line is placed on the outside, no insulation of the heat-exchanger is necessary. Thus, the following costs for twenty feet of heat exchanger:

Liquid Line Inside	
1⅛ in. OD Tubing	$3.76
3⅛ in. OD Tubing	17.40
3⅛ in. Ice-water cork	14.00
Total	$35.16
Suction Line Inside	
2⅝ in. OD Tubing	$13.20
3⅛ in. OD Tubing	17.40
Total	$30.60

While the foregoing prices are neither accurate nor recent and do not include the cost of fittings or labor, they do, nevertheless, serve as a rough comparison of the costs of the two methods. It is worthy of mention in passing that the overall diameter of the insulated heat-exchanger mentioned would be 6 in. as compared with the 3⅛ in. of the uninsulated one. This fact may sometimes be of considerable interest.

Since, therefore, considerations of heat transfer surface, overall cost, and overall size all favor a liquid vapor heat-exchanger with the suction line inside the liquid line, attention will henceforth be given only to such a construction as that illustrated in Fig. 3. Here is a heat exchanger constructed on the job, of standard tubing and fittings. It is effective and inexpensive. However, since, except on special order, standard tubing comes out from the factory in twenty-foot lengths, heat-exchangers of this design must be constructed in twenty-foot sections joined together either in straight line or return bend fashion, depending upon the separation between compressor and evaporator.

Use of Design Charts

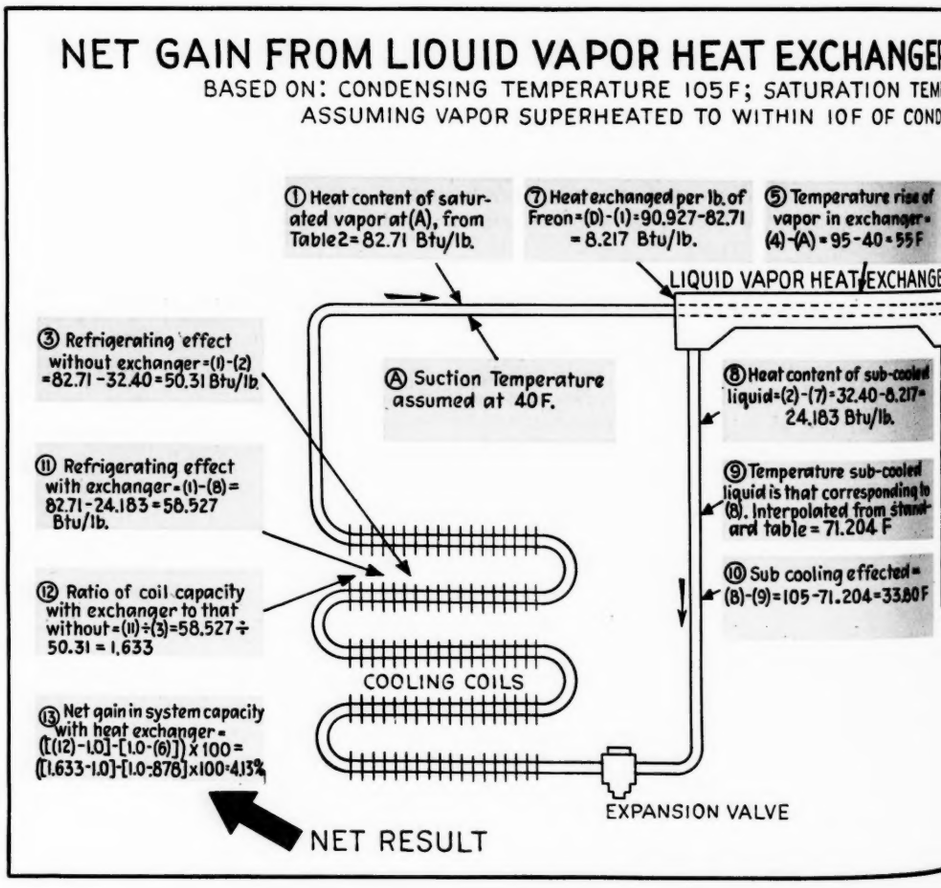
So far no information has been given on determining the length of the heat exchanger. It is for this purpose that a series of six charts (Figs. 4 to 9, inclusive) is presented, and the construction of which is fully explained later under the heading "Formula Derivation."

Figs. 4 to 9 cover conditions of three suction gas temperatures (30, 40 and 50F) for two condensing temperatures (105 and 115F) just as does Table 4. Use of these charts is best explained by examples.

Example: A 12 ton system with a 2⅛ in. O.D. suction line, operating on a suction temperature of 40F and a condensing temperature of 105F, is to have a liquid-vapor heat exchanger installed. The diameter of the exchanger has been determined as explained before. What length should it be?

Solution: Up to the theoretical maximum limitations on net gain in capacity to be expected, the length depends on the net gain to be attained. Refer to Fig. 5. Locate 12 on the lower scale, move vertically to the 2⅛ suction line curve, thence horizontally to 20 ft (length of exchanger line), thence vertically and read 1.96% as the net gain in capacity to be gotten with a 20 ft exchanger. If a 30 ft exchanger were used, the net gain would be 2.70%. If a 50 ft exchanger were used, the increase in capacity would be 3.65%; for a 70 ft exchanger, 4.20%; for a 100 ft exchanger, 4.70%; for a 150 ft exchanger, 5.0% increase.

It is seen that increasing the length yields a diminishing return, and that the length of exchanger depends on the selection, by the designer, of that net gain which he feels is justifiable in view of addi-


NET GAIN FROM LIQUID VAPOR HEAT EXCHANGE
BASED ON: CONDENSING TEMPERATURE 105 F; SATURATION TEM
ASSUMING VAPOR SUPERHEATED TO WITHIN 10F OF COND
① Heat content of saturated vapor at (A), from Table 2 = 82.71 Btu/lb.
⑦ Heat exchanged per lb. of Freon = (D)-(1) = 90.927-82.71 = 8.217 Btu/lb.
⑤ Temperature rise of vapor in exchanger = (4)-(A) = 95-40 = 55 F
LIQUID VAPOR HEAT EXCHANGE
③ Refrigerating effect without exchanger = (1)-(2) = 82.71 - 32.40 = 50.31 Btu/lb
Ⓐ Suction Temperature assumed at 40 F.
⑧ Heat content of sub-cooled liquid = (2)-(7) = 32.40-8.217 = 24.183 Btu/lb.
⑪ Refrigerating effect with exchanger = (1)-(8) = 82.71-24.183 = 58.527 Btu/lb.
⑨ Temperature sub-cooled liquid is that corresponding to (8). Interpolated from standard table = 71.204 F
⑫ Ratio of coil capacity with exchanger to that without = (11) ÷ (3) = 58.527 ÷ 50.31 = 1.633
⑩ Sub cooling effected = (8)-(9) = 105 - 71.204 = 33.80 F
COOLING COILS
⑬ Net gain in system capacity with heat exchanger = ([(12)-1.0]-[1.0-(6)]) x 100 = ([1.633-1.0]-[1.0-.876]) x 100 = 4.13%
EXPANSION VALVE
NET RESULT

Note: In connection with the sizing of the liquid line and suction lines themselves see How to Determine Size and Cost of Freon Lines, by William Parkerson, Heating and Ventilating, October, 1940.

tional exchanger length and, in addition, of course, on the space limitation of the system.

Example: A 78 ton system with a 4⅛ in. suction line, 40F suction temperature, 105F condensing temperature, is so arranged that an exchanger no more than 100 ft long could be used. What would be the net gain in capacity if this system is installed with an exchanger?

Solution: Refer to Fig. 5. Move vertically from 78 to the 4⅛ suction line curve, thence horizontally to the 100 ft. length curve and, moving vertically to the top scale, find 3.2% as the increase to be obtained. A 70 ft exchanger would give a 2.6% increase.

The actual design of an exchanger can all be summarized as follows. Only Table 6 and Figs. 4 to 9 are needed:

(1) In Table 6, locate the diameter of the liquid line in column 1; in column 2 find its inside cross-sectional area; this area (or the next larger area) is needed in the annular space;

(2) In Table 6 locate the diameter of the suction line in column 1; move horizontally to the figure next larger than the area found in (1);

(3) Move vertically up and find the diameter of the outside tube of the exchanger. The inside tube is, of course, the original suction line size;

(4) Select the proper chart (Figs. 4 to 9) depending on the suction and condensing temperatures;

(5) On the proper chart, locate the tonnage of the system, move vertically to the curve representing the diameter of the suction line;

(6) From this intersection move horizontally to the curve representing the length of the exchanger;

(7) From the intersection move vertically up and read the net gain in capacity resulting from use of an exchanger of that length.

Example: A system of 30 tons operating on a suction temperature of 30F and a condensing temperature of 105F has a suction line of 3⅛ in. O. D. tubing and a liquid line of 1⅜ in. O. D. tubing. What will be the dimensions of the exchanger and the resulting increase in capacity?

Solution: In Table 6, opposite 1⅜ in column 1, find 1.256 as the necessary annular area. Opposite 3⅛ in column 1, move horizontally and find 1.543 as the first figure larger than 1.256. Move vertically up and find the outside pipe of the exchanger to be 3⅝ in. O. D. The inside tube will be 3⅛, the suction line size.

For a suction temperature of 30F and a condensing temperature of 105F, the proper chart is Fig. 4. Enter on the lower scale at 30, move vertically to 3⅛ thence horizontally to the length curves, then vertically, and find a net gain in capacity of 2.4% for a 30 ft long exchanger, 3.6% for 50 ft, 4.4% for 70 ft, 5.2% for 100 ft, 5.8% for 150 ft, and 6.3% for 200 ft. Select the length which seems economically and practically the most desirable.

TABLE 3.—PROPERTIES OF SUPERHEATED FREON-12 VAPOR.

Temperature, F	Gauge Pressure, Lb per Sq In.					
	28.46	36.98	46.69	28.46	36.98	46.69
	Saturation Temperature, F					
	30	40	50	30	40	50
	Specific Volume, Cu Ft per Lb			Heat Content, Btu per Lb		
At Saturation	.939	.792	.673	81.61	82.71	83.78
60	1.0104	.8328	.6926	85.989	85.661	85.276
65	1.0219	.8429	.7014	86.732	86.407	86.030
70	1.0334	.8529	.7102	87.475	87.153	86.784
75	1.0451	.8629	.7186	88.220	87.903	87.540
80	1.0568	.8729	.7270	88.965	88.653	88.296
85	1.0683	.8825	.7353	89.715	89.408	89.056
90	1.0798	.8921	.7437	90.465	90.163	89.817
95	1.0913	.9021	.7525	91.221	90.927	90.587
100	1.1027	.9121	.7613	91.975	91.691	91.357
104	1.1121	.9197	.7679	92.587	92.307	91.978
105	1.1144	.9216	.7696	92.740	92.461	92.133
110	1.1261	.9312	.7780	93.505	93.231	92.909
114	1.1351	.9392	.7847	94.122	93.850	93.530
115	1.1373	.9412	.7864	94.277	94.005	93.685
120	1.1485	.9512	.7949	95.049	94.780	94.461

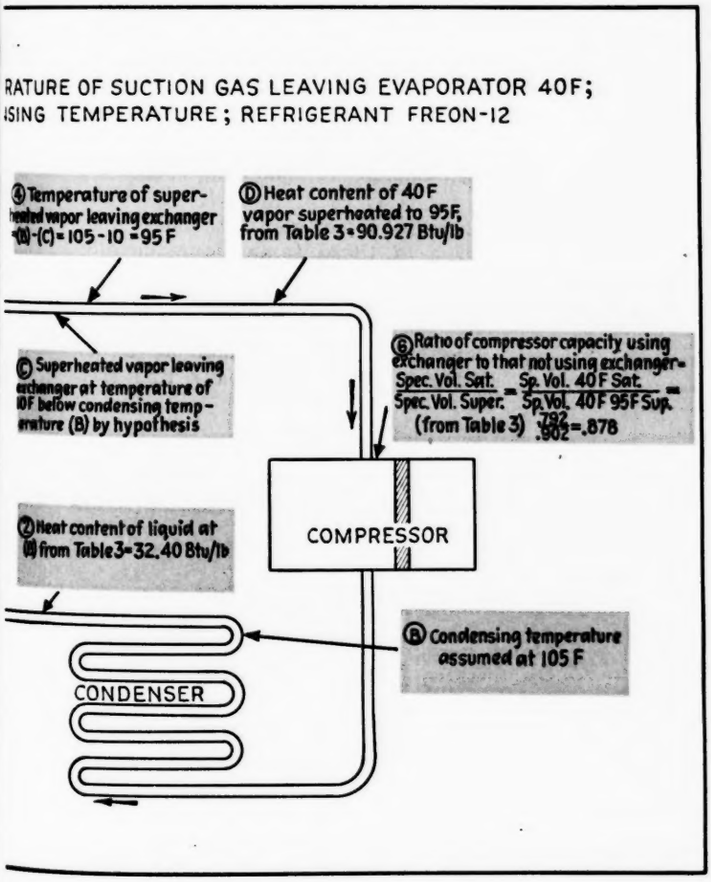

RATURE OF SUCTION GAS LEAVING EVAPORATOR 40F;
ISING TEMPERATURE; REFRIGERANT FREON-12
④ Temperature of superheated vapor leaving exchanger (A)-(C)=105-10=95 F
Ⓓ Heat content of 40 F vapor superheated to 95F, from Table 3=90.927 Btu/lb
Ⓒ Superheated vapor leaving exchanger at temperature of 10F below condensing temperature (B) by hypothesis
⑥ Ratio of compressor capacity using exchanger to that not using exchanger = Spec. Vol. Sat. / Spec. Vol. Super. = Sp. Vol. 40 F Sat. / Sp. Vol. 40 F 95 F Sup. (from Table 3) .792/.902=.878
COMPRESSOR
② Heat content of liquid at (A) from Table 3=32.40 Btu/lb
Ⓑ Condensing temperature assumed at 105 F
CONDENSER

Fig. 1. Small figures refer to item numbers. Also see Table 4.

Formula Derivation

[The material under this head explains the formula used in developing Figs. 4 to 9 but is not necessary in connection with use of these charts.]

The formula for the required length of a heat-exchanger of the adopted design to produce the determined results through a transfer of heat from the liquid to the vapor refrigerant, is derived as follows:

The starting point in this derivation is the formula for U, the coefficient of heat transfer for any gas in turbulent flow within a tube.[1] Knaus experimentally confirmed this formula[2] for Freon-12 in a double-pipe counter-flow heat-exchanger constructed of copper tubing and having the vapor line on the inside of the liquid line, such as considered here.

In his article, Knaus has the following enlightening remarks to make: "Two film coefficients are involved in an interchanger, that for the vapor film and that for the liquid film. For the concentric tube type, with the vapor in the central tube, the cross section of the vapor tube will normally be in the range of one to four times the cross section of the annular liquid space. Very

[1]See the *Data Book*, American Society of Refrigerating Engineers, 4th Edition, page 150.

[2]Heat Interchangers in Commercial Refrigeration, by W. L. Knaus; *Refrigerating Engineering*, July, 1937, page 21.

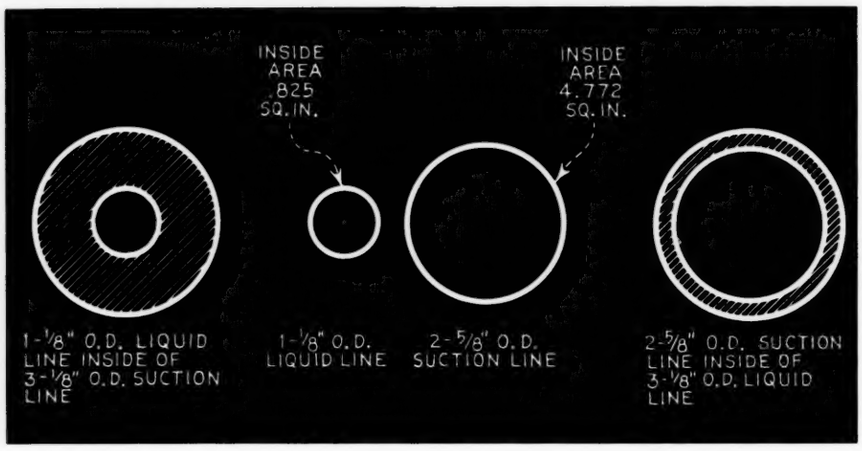

INSIDE AREA .825 SQ. IN.
INSIDE AREA 4.772 SQ. IN.
1-⅛" O.D. LIQUID LINE INSIDE OF 3-⅛" O.D. SUCTION LINE
1-⅛" O.D. LIQUID LINE
2-⅝" O.D. SUCTION LINE
2-⅝" O.D. SUCTION LINE INSIDE OF 3-⅛" O.D. LIQUID LINE

Fig. 2. Relative sizes and annular areas of tubing heat exchanger with liquid line inside and outside of suction line.

approximate estimates based on McAdams' equation indicate that the liquid film coefficient will be several times greater than the vapor film coefficient. It therefore becomes reasonable to consider an equation based only on the size of the vapor tube and the vapor velocity, with which to predict overall heat transfer coefficients in an interchanger of the type mentioned."

Beginning with the heat transfer formula,

$$U = 36 C_p G^{.8} \left(\frac{Z}{d} \right)^{.2} \quad \ldots\ldots (1)$$

where U = heat transfer, Btu per sq ft per hr per F
C_p = specific heat at constant pressure, Btu per lb per F
G = mass velocity, lb per sq ft per sec
Z = viscosity in centipoises, and
d = inside pipe diameter, inches

By definition, $G = \frac{\text{lb}}{\text{sec} \times \text{sq ft}}$

$$G = \frac{\text{lb}}{60 \times \text{min} \times \text{sq ft}} \quad \ldots\ldots (2)$$

and if T = tons of refrigeration

$$G = \frac{\text{lb} \times T \times 144}{60 \times \text{min} \times \text{sq in} \times T}$$

$$G = \frac{9.6}{\pi} \times \frac{\text{lb}}{\text{min} \times T} \times \frac{T}{d^2} \quad \ldots (3)$$

If we designate $\frac{\text{lb}}{\text{min} \times T}$ as W, we have

$$G = \frac{9.6}{\pi} \times W \times \frac{T}{d^2} \quad \ldots\ldots (4)$$

Substituting (4) in (1):

$$U = 36 C_p \left(\frac{9.6}{\pi} \right)^{.8} (WT)^{.8} \left(\frac{1}{d^2} \right)^{.8} \left(\frac{Z}{d} \right)^{.2}$$

$$U = 87.984 C_p (WT)^{.8} Z^{.2} \frac{1}{d^{1.8}} \quad \ldots (5)$$

The heat transferred per minute is equal to the heat transferred per pound of refrigerant (H) times the pounds of refrigerant circulated per minute per ton times the number of tons or

$$\frac{\text{Btu}}{\text{min}} = H \times W \times T = \frac{\text{Btu}}{\text{hr}} \div 60$$

from which

$$\frac{\text{Btu}}{\text{hr}} = 60 \times H \times W \times T \quad \ldots\ldots (6)$$

The heat transferred per hour may also be expressed as

$$\frac{\text{Btu}}{\text{hr}} = U \times A \times D \quad \ldots\ldots (7)$$

where A = area in sq ft
D = log mean temperature difference, F

Equating (7) and (6) and for A substituting $A = L \times \frac{\pi d}{12}$

where L = length of exchanger in feet,

$$U \times L \times \frac{\pi d}{12} \times D = 60 \times H \times W \times T$$

or

$$L = 229.18 \frac{H \times W \times T}{U \times d \times D} \quad \ldots\ldots (8)$$

Substituting (5) in (8):

$$L = \frac{229.18}{87.984} \times \frac{H \times W \times T \times d^{1.8}}{C_p \times W^{.8} \times T^{.8} \times Z^{.2} \times d \times D}$$

$$L = \left[2.605 d^{.8} T^{.2} \right] \times \left[\frac{H}{C_p D} \times \left(\frac{W}{Z} \right)^{.2} \right]$$

the foregoing equation can be designated (9). The two bracketed terms above can be designated X and Y, and we have:

$$L = X \times Y \quad \ldots\ldots (10)$$

The net results of the foregoing operations is the formula L=X×Y, wherein X represents the gathering together of all terms in the final equation which are dependent only on pipe size and tonnage of refrigeration; and Y all terms dependent both directly and indirectly on refrigerant conditions.

The values of X are given in Table 7 for a number of pipe sizes and for two selected refrigerating capacities.

Items 14 to 21 inclusive, in Table 4, taken step-by-step with the explanation of these same items develop the values of Y. Having these two sets of values, we may determine, by their product, the necessary length of heat-exchanger at either selected tonnage, for any line size,

Fig. 3. Arrangement of job-made liquid vapor heat exchanger.

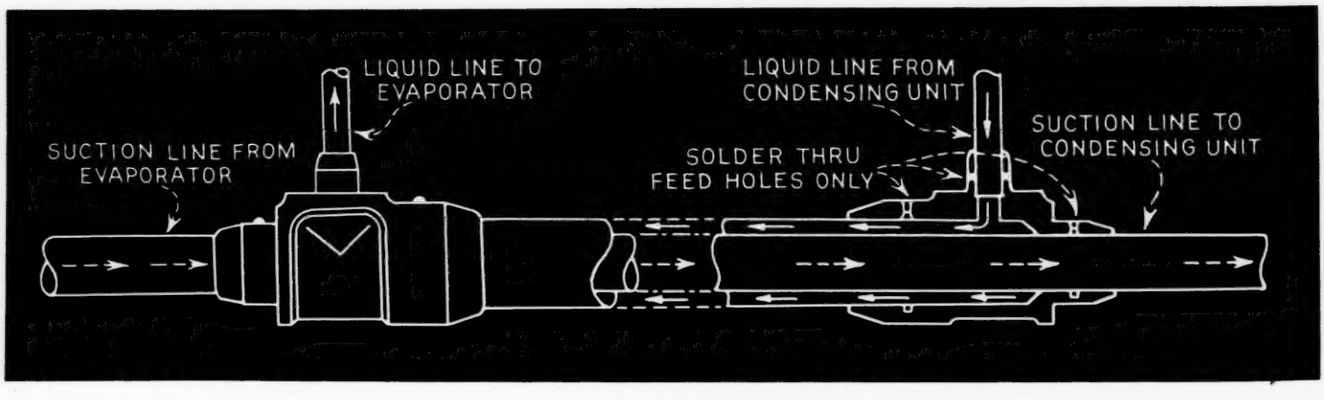

LIQUID LINE TO EVAPORATOR
LIQUID LINE FROM CONDENSING UNIT
SUCTION LINE TO CONDENSING UNIT
SUCTION LINE FROM EVAPORATOR
SOLDER THRU FEED HOLES ONLY

TABLE 4.—NET INCREASE IN REFRIGERATION CAPACITY DUE TO DOUBLE-PIPE LIQUID-VAPOR COUNTER-FLOW HEAT EXCHANGER.

(Assuming the Refrigerant (Freon-12) Vapor Superheated to Within Ten Degrees of Condensing Temperature)

Item No.	Item	Condensing Temperature, 105F			Condensing Temperature, 115F		
		Saturation Temperature of Suction Gas Leaving Evaporator					
		30F	40F	50F	30F	40F	50F
1	Heat Content of Saturated Vapor—Btu per lb	81.61	82.71	83.78	81.61	82.71	83.78
2	Heat Content of Liquid at Saturation—Btu per lb	32.40	32.40	32.40	34.90	34.90	34.90
3	Refrigeration Effect without Heat Exchanger—Btu per lb	49.21	50.31	51.38	46.71	47.81	48.88
4	Temperature of Superheated Vapor, F.	95	95	95	105	105	105
5	Vapor Temperature Rise or Superheat, F.	65	55	45	75	65	55
6	Ratio of Capacities—Superheating	.8604	.8780	.8944	.8426	.8594	.8745
7	Total Heat Exchanged per Pound of Freon—Btu per lb	9.611	8.217	6.807	11.130	9.751	8.353
8	Heat Content of Sub-cooled Liquid—Btu per lb	22.789	24.183	25.593	23.770	25.149	26.547
9	Temperature of Sub-cooled Liquid, F.*	65.300	71.204	77.138	69.458	75.288	81.113
10	Liquid Temperature Drop or Sub-cooling Effected, F	39.70	33.80	27.86	45.54	39.71	33.89
11	Refrigeration Effect with Heat Exchanger—Btu lb	58.821	58.527	58.187	57.840	57.561	57.233
12	Ratio of Capacities—Sub-cooling	1.1953	1.1633	1.1325	1.2383	1.2040	1.1709
13	Net Gain in Capacity from Heat Exchanger, %	5.57	4.13	2.69	8.09	6.34	4.54
14	Large Temperature Difference, F	35.300	31.204	27.138	39.458	35.288	31.113
15	Small Temperature Difference, F	10	10	10	10	10	10
16	Logarithmic Mean Temperature Difference, F	20.059	18.633	17.166	21.460	20.054	18.601
17	Freon Circulated—Pounds per Minute per Ton	3.400	3.417	3.437	3.458	3.475	3.494
18	Average Viscosity of Vapor for Temp. Range—Centipoises	.0123	.0124	.0125	.0124	.0125	.0126
19	$(w/z)^{0.2}$	3.0783	3.0764	3.0750	3.0838	3.0819	3.0803
20	Average Specific Heat of Vapor for Temperature Range—Btu per lb per deg	.1479	.1494	.1513	.1484	.1500	.1519
21	Value of Y	9.972	9.139	8.059	10.778	9.990	9.106

*Assuming that the specific heat of the liquid is not appreciably affected by changes in pressure.

DEVELOPMENT OF ITEMS IN TABLE 4

As calculated for condensing temperature of 105F and saturated suction temperature of 40F, as emphasized in color above. The first 13 items are shown graphically in Fig. 1

Item 1. Heat Content of Saturated Vapor
Taken from Table 1 as 82.71 Btu per lb.

Item 2. Heat Content of Liquid at Saturation
Taken from Table 1 as 32.40 Btu per lb.

Item 3. Refrigeration Effect without Heat Exchanger
= Heat of Vapor—Heat of Liquid
= 82.71—32.40 = 50.31 Btu per lb.

Item 4. Temperature of Superheated Vapor
= Condensing temperature—10F
= 105F—10F = 95F

Item 5. Vapor Temperature Rise or Superheat
= Condensing temperature—10—Suction temperature
Item (4)—Saturated Section Temperature
= 95.40 = 55F

Item 6. Ratio of Capacities, Superheating
= (Specific volume of saturated vapor) ÷ (Sp. vol. of superheated vapor)
= .792 ÷ .9021 = .8980 (See Table 2)

Item 7. Total Heat Exchanged per Pound of Freon
= Heat content of superheated vapor—Heat content of saturated vapor
= 90.927—82.71 = 8.217 Btu per lb. (See Table 2)

Item 8. Heat Content of Sub-cooled Liquid
= Heat of Liquid at Saturation—Heat exchanged
= 32.40—8.217 = 24.183 Btu per lb.

Item 9. Temperature of Sub-cooled Liquid,
= Temperature of Liquid corresponding to heat content of sub-cooled liquid
Found, by interpolation in standard table, to be 71.204

Item 10. Liquid Temperature Drop or Sub-cooling Effected
= Condensing Temperature—Temperature of sub-cooled liquid
= 105F—71.204F = 33.80 Btu per lb.

Item 11. Refrigeration Effect with Heater Exchanger, Btu per lb.
= Heat content of vapor—Heat content of sub-cooled liquid
= 82.71—24.183 = 58.527 Btu per lb.

Item 12. Ratio of Capacities—Sub-cooling

$$= \frac{\text{Refrigeration effect with heat exchanger}}{\text{Refrigeration effect without heat exchanger}} = 58.527 \div 50.31 = 1.1633$$

Item 13. Net Gain in Capacity from Heat Exchanger—%
= Percent gain—percent loss
= [(Item 12—1.0) — (1.0—Item 6)]100
= [(1.1633—1.0) — (1.0—.878)]100
= (.1633—.122)100 = 4.13%

Item 14. Large Temperature Difference, F
= Temperature of leaving liquid—temperature of entering vapor
= 71.204—40 = 31.204F

Item 15. Small Temperature Difference, F
= Temperature of entering liquid—temperature of leaving vapor
= 10F, by hypothesis

Item 16. Logarithmic Mean Temperature Difference, F

$$= \frac{\text{Large temperature difference—Small temperature difference}}{\text{Log}_e \dfrac{\text{Large temperature difference}}{\text{Small temperature difference}}}$$

$$= \frac{31.204 - 10}{\text{Log}_e \dfrac{31.204}{10}} = 18.633$$

Item 17. Freon Circulated, Pounds per Minute per Ton

$$= \frac{\text{Btu per minute per ton}}{\text{Refrigeration effect}} = 200 \div \text{Item 11}$$

$$= \frac{200}{\text{ton}} \div 58.527 = 3.417 \text{ lb per min per ton}$$

Item 18. Average Viscosity of Vapor for Temperature Range, Centipoises

$$= \frac{.0119 + .0128}{2} = .01235 \text{ centipoises}$$

(See Table 8)

Item 19. $(w/z)^{.2}$ = (Item 17 ÷ Item 18)$^{.2}$ = (3.417 ÷ .01235)$^{.2}$ = 3.0764

Item 20. Average Specific Heat of Vapor for Temperature Range, Btu per lb per deg

$$= \frac{\text{Item 7}}{\text{Item 5}} = \frac{8.217}{55} = .1494$$

Item 21. Y

$$= \frac{(\text{Heat exchanged}) \times (w/z)^{.2}}{(\text{Avg. sp. ht. of vapor}) \times (\text{Log mean temp. difference})}$$

$$= \frac{(\text{Item 7}) \times (\text{Item 19})}{(\text{Item 20}) \times (\text{Item 16})}$$

$$= \frac{8.217 \times 3.0764}{.1494 \times 18.633} = 9.139$$

and for any set of refrigerant conditions studied, assuming a Small Temperature Difference, as previously defined, of 10F.

In Table 4, values of Net Gain in Capacity (Item 13) are associated with values of Y (Item 21) for six different sets of refrigerant conditions; but for only one value of the Small Temperature Difference (Item 15), namely 10F. Thus, for any set of refrigerant conditions (say, condensing temperature of 105F and suction temperature of 40F), Table 4 provides only one point on a curve.

TABLE 5.—DATA ON GOVERNMENT TYPE L COPPER TUBING.

Tube Size, O.D., In.	Diameter, Inches		Cross Section Area, Square Inches		Surface, Square Feet per Lineal Foot	
	O.D.	I.D.	Outside	Inside	Outside	Inside
⅜	.375	.315	.110	.078	.098	.082
½	.500	.430	.196	.146	.131	.113
⅝	.625	.545	.307	.233	.164	.143
¾	.750	.666	.442	.348	.196	.174
⅞	.875	.785	.601	.484	.229	.206
1 ⅛	1.125	1.025	.994	.825	.295	.268
1 ⅜	1.375	1.265	1.485	1.256	.360	.331
1 ⅝	1.625	1.505	2.074	1.779	.425	.394
2 ⅛	2.125	1.985	3.547	3.095	.556	.520
2 ⅝	2.625	2.465	5.412	4.772	.687	.645
3 ⅛	3.125	2.945	7.670	6.812	.818	.772
3 ⅝	3.625	3.425	10.320	9.213	.950	.902
4 ⅛	4.125	3.905	13.364	11.977	1.080	1.024
5 ⅛	5.125	4.875	20.629	18.666	1.342	1.278
6 ⅛	6.125	5.845	29.465	26.832	1.604	1.530

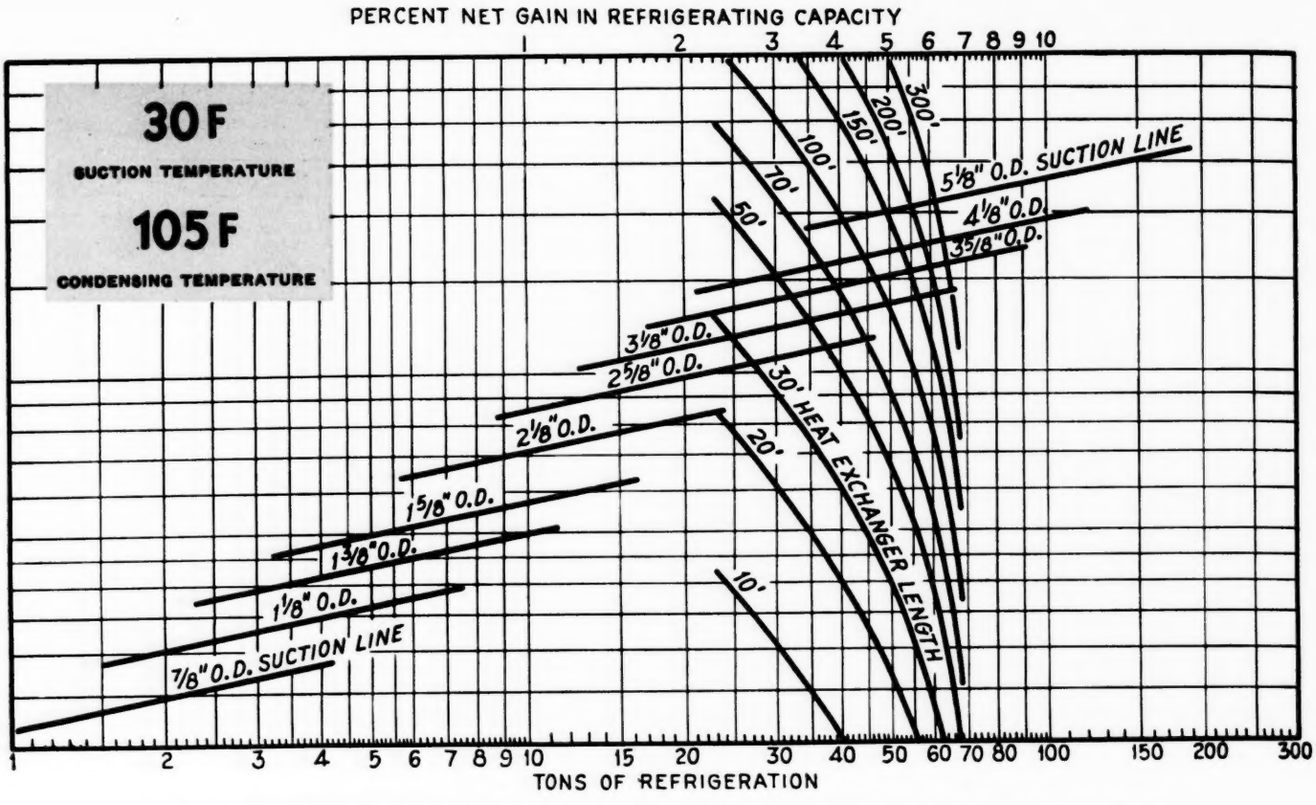


Fig. 4. Net gain-length chart for 30F suction temperature, 105F condensing temperature.

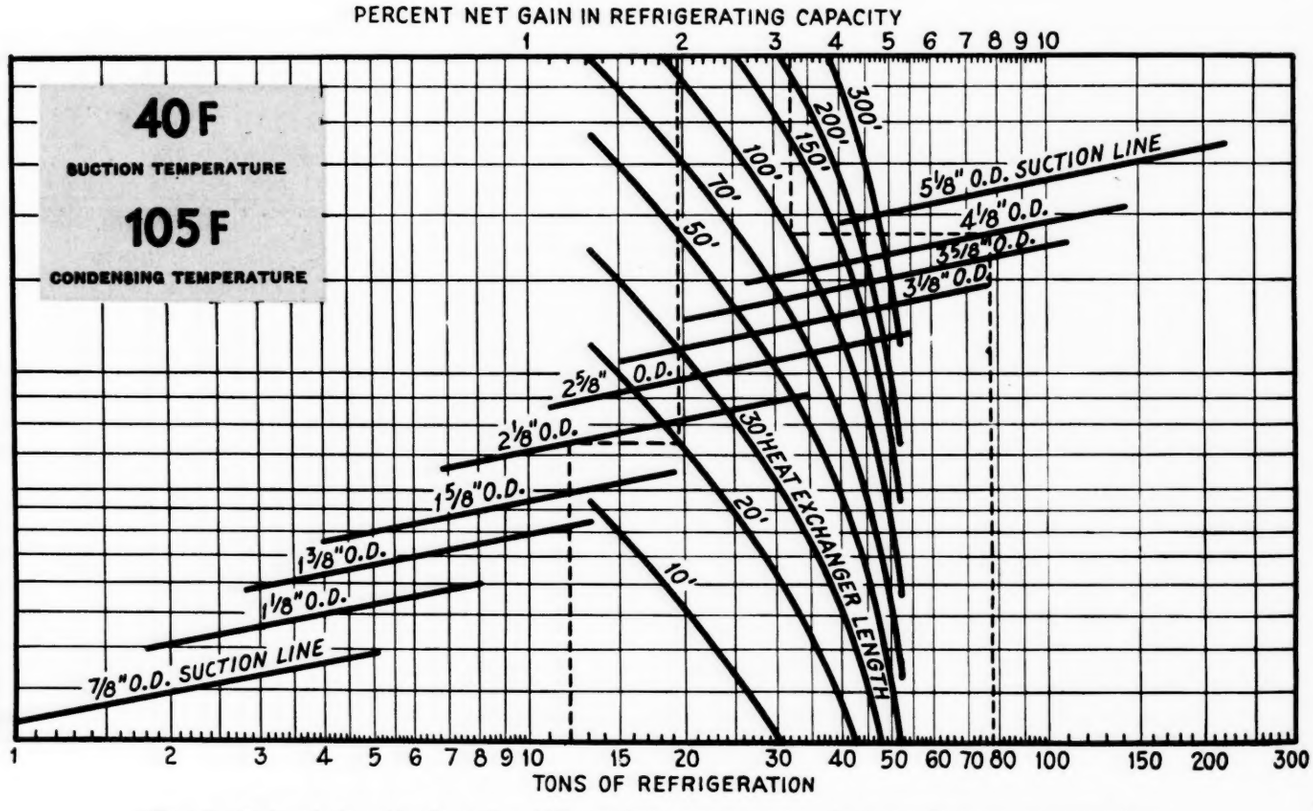


Fig. 5. Net gain-length chart for 40F suction temperature, 105F condensing temperature.

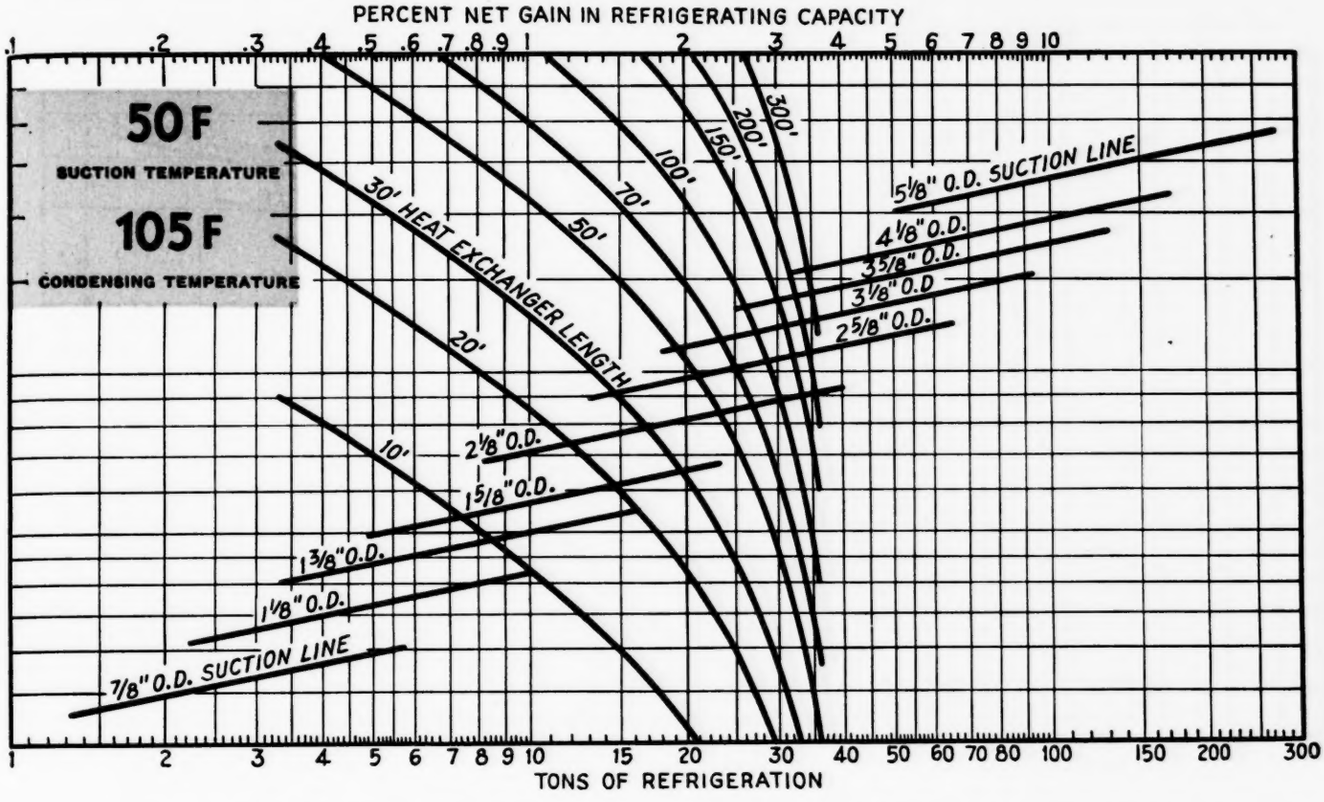


Fig. 6. Net gain-length chart for 50F suction temperature, 105F condensing temperature.

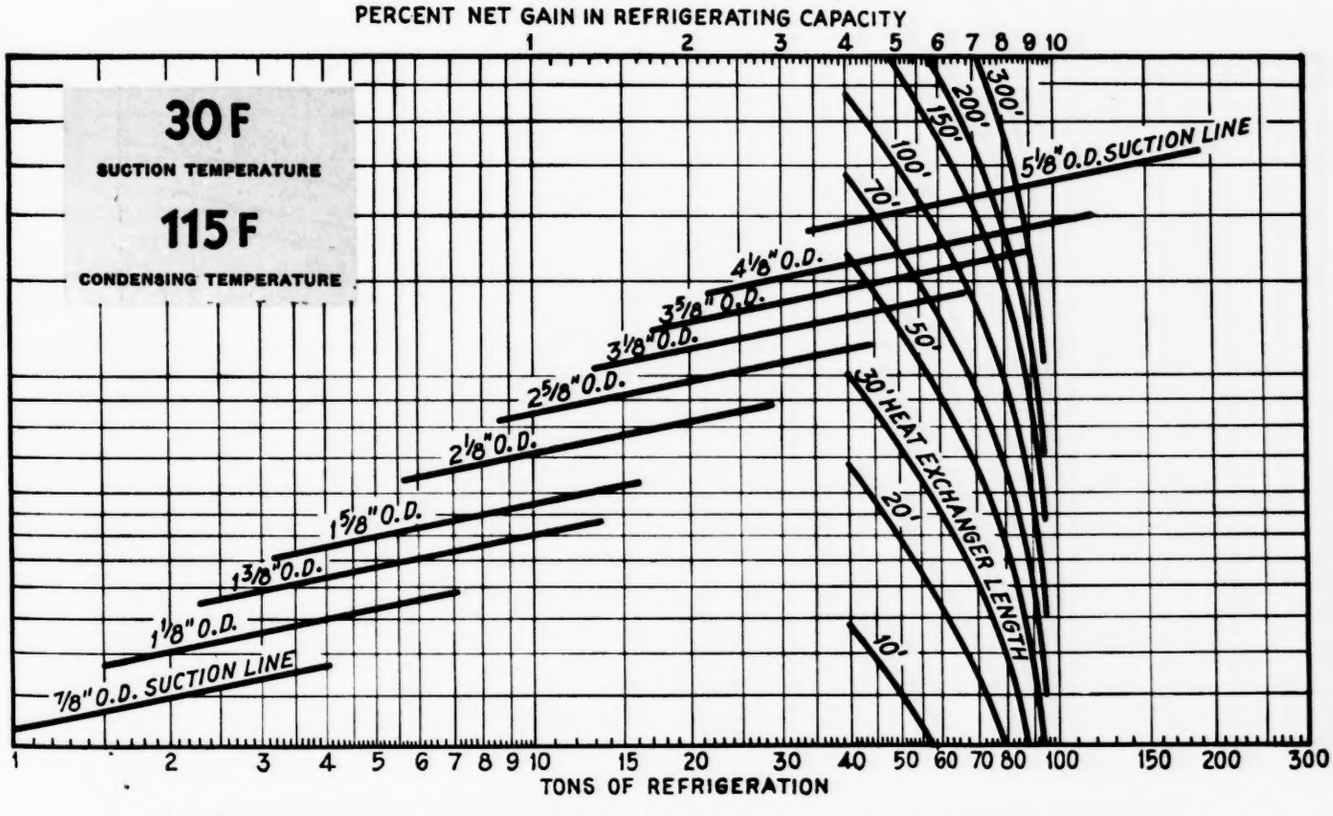


Fig. 7. Net gain-length chart for 30F suction temperature, 115F condensing temperature.

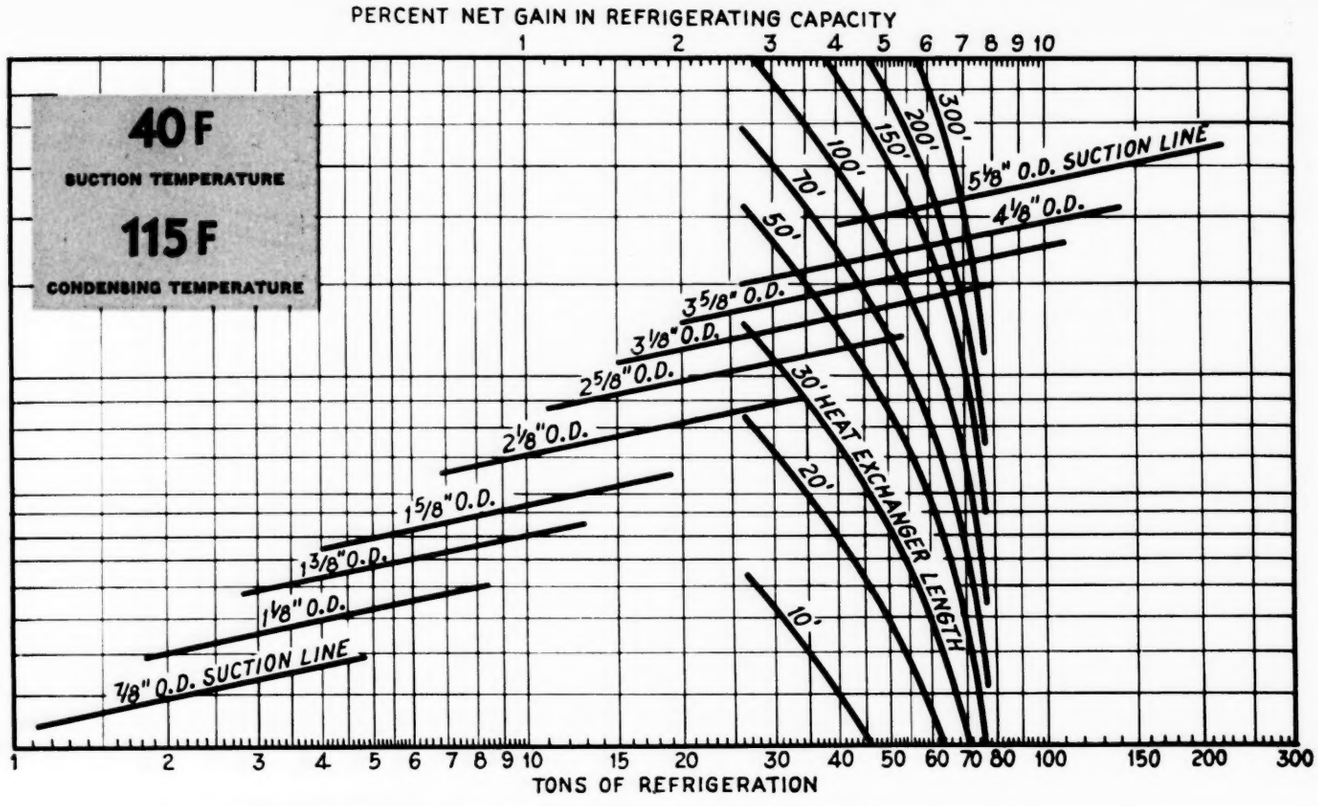


Fig. 8. Net gain-length chart for 40F suction temperature, 115F condensing temperature.

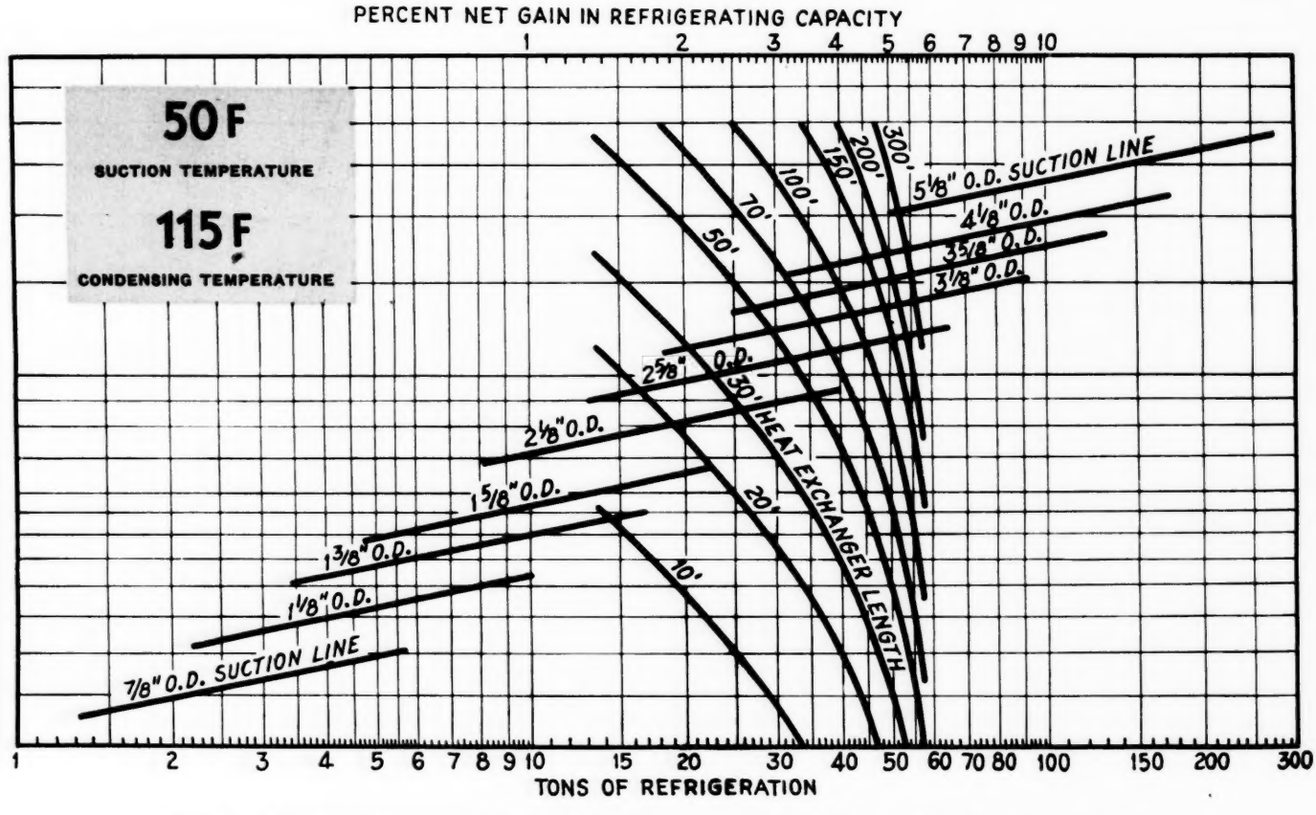


Fig. 9. Net gain-length chart for 50F suction temperature, 115F condensing temperature.

TABLE 6.—NET ANNULAR AREA BETWEEN TWO CONCENTRIC TYPE L COPPER PIPES

Inside Pipe Diam. Inches, O.D.	Inside Area, Sq. In.	Size of Outside Pipe, Inches, O.D.													
		1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8	5-1/8	6-1/8
		Annular Area, Square Inches													
3/8	.078	.036	.123	.238	.374	.715	1.146	1.669	2.985	4.662	6.702	9.103	11.867	18.556	26.722
1/2	.146		.037	.152	.288	.629	1.060	1.583	2.899	4.576	6.616	9.017	11.781	18.470	26.636
5/8	.233			.041	.177	.518	.949	1.472	2.788	4.465	6.505	8.906	11.670	18.359	26.525
3/4	.348				.042	.383	.814	1.337	2.653	4.330	6.370	8.771	11.535	18.224	26.390
7/8	.484					.224	.655	1.178	2.494	4.171	6.211	8.612	11.376	18.065	26.231
1-1/8	.825						.262	.785	2.101	3.778	5.818	8.219	10.983	17.672	25.838
1-3/8	1.256							.295	1.610	3.287	5.327	7.728	10.492	17.181	25.347
1-5/8	1.779								1.021	2.698	4.738	7.139	9.903	16.592	24.758
2-1/8	3.095									1.225	3.265	5.666	8.430	15.119	23.285
2-5/8	4.772										1.400	3.801	6.565	13.254	21.420
3-1/8	6.812											1.543	4.307	10.996	19.162
3-5/8	9.213												1.657	8.346	16.512
4-1/8	11.977													5.302	13.468
5-1/8	18.666														6.203

TABLE 7.—VALUES OF X FOR VARIOUS TUBE SIZES AND REFRIGERATION TONNAGE

(Based on $X = 2.605d^{-5}\ T^{-2}$, where d is the inside tube diameter, T the tonnage.)

Tube Size, In., O.D.	d	d^{-5}	X	
			T = 10	T = 100
3/8	.315	.3969	1.6385	2.5969
1/2	.430	.5091	2.1018	3.3311
5/8	.545	.6010	2.4815	3.9330
3/4	.666	.7224	2.9825	4.7270
7/8	.785	.8239	3.4018	5.3915
1 1/8	1.025	1.0200	4.2112	6.6744
1 3/8	1.265	1.2069	4.9829	7.8973
1 5/8	1.505	1.3868	5.7256	9.0745
2 1/8	1.985	1.7306	7.1451	11.3242
2 5/8	2.465	2.0580	8.4968	13.4665
3 1/8	2.945	2.3728	9.7965	15.5264
3 5/8	3.425	2.6775	11.0545	17.5202
4 1/8	3.905	2.9737	12.2774	19.4584
5 1/8	4.875	3.5512	14.6617	23.2373
	$10^{-2} = 1.585$		$100^{-2} = 2.512$	

To plot a curve, more points are needed. Therefore, four other tables similar to Table 4 were compiled; one for each of the following Small Temperature Differences—1F, 5F, 20F, and 40F. From these five tables we may, for each of the six sets of refrigerant conditions, prepare a table similar to Table 9, which is for a condensing temperature of 105F and a suction temperature of 40F.

Fortified now with Table 7 and Table 9, we are ready to construct Fig. 5. Using the left-hand vertical scale for values of "X," we may from Table 7, for, say, the 2⅛ in. O. D. line, plot T = 10 against X = 7.1451 and T = 100 against X = 11.3242 and, using these two points for direction, draw a straight line through the range of economy for this size line. Similarly we may draw lines of relationship between "T" and "X" for all other sizes of lines.

Now, using the same left-hand vertical scale for the same values of "X", we may from Table 9, for an assumed heat-exchanger length, "L", equal to twenty feet, plot the five points: Net Gain = 5.20 against X = .770, Net Gain = 4.67 against X = 1.45, Net Gain = 4.13 against X = 2.171, et cetera, and draw a smooth curve through these five points. This same procedure may be followed for each of the assumed values of "L".

In this way "X" and "Y" are both, we may say, checked out of the picture and there remains a complete chart of the significant variables. Thus also were the other five charts constructed. Fig. 4 and Figs. 6 to 9.

It should be noted in passing that the area of the heat transfer surface may easily be found by multiplying the length of the heat-exchanger by the proper figure selected from the last column of Table 5, allowing figures in the first column thereof to represent suction line sizes.

Discussion and Conclusion

As already pointed out, a glance at the charts will show a wide range in the "Percent Net Gain." No conservative person, having these charts before him, would make any general statement as to a fixed net gain to be expected from the installation of a heat-exchanger. Too much depends on too many variables. Compare, for example, Fig. 6 with Fig. 7.

In a job-made liquid vapor heat exchanger consideration of surface area, cost, and size all favor a liquid vapor heat exchanger with the suction line inside the liquid line.

From a very rapid and rough side study, it seems that, for a given condensing temperature and a given "Small Temperature Difference," the "Percent Net Gain" may be a straight-line function of the saturated suction temperature; though why this should be, is not clear to the writer, nor does it appear to be a simple question to answer. It may be deserving of further study. However, if this simple relation does exist, a 15% net gain is not attained, even with 115F condensing temperature and 1F "Small Temperature Difference," above a suction temperature of 1F.

Comparing Figs. 8 and 5 and then Figs. 4 and 5 it may be seen that the "Percent Net Gain" is somewhat more sensitive to changes in condensing temperature than to changes in suction temperature. Of course, the "Percent Net Gain" increases as the separation between the suction and condensing temperatures becomes greater.

It is interesting to note what an important role the suction line size plays. Consider the first example explaining Fig. 5 (under Design Charts) and note that, for the same tonnage and the same heat-exchanger length, if a 1⅝ in. O. D. suction line had been used, the net gain would have been 2.32% instead of 1.96% for the 2⅛ in. O. D. line. This is due to the fact that as the size of

TABLE 8.—ABSOLUTE VISCOSITY OF FREON-12 VAPOR IN CENTIPOISES AT PRESSURE OF ONE ATMOSPHERE

Temp., F	Vis.
30	.0118
40	.0119
50	.0121
65	.0124
75	.0125
85	.0127
95	.0128
100	.0129
104	.0130
105	.0130
110	.0131
114	.0131
115	.0131

the whole suction line would have to control the sizing of the suction line.*

In conclusion, it would appear from this discussion that, under normal refrigerant conditions, a substantial improvement in economy of operation may generally be secured by the installation of a heat-exchanger. However, even if a heat-exchanger of the kind considered herein achieved *no* net gain in refrigerating capacity *per se*, it still would offer two worthwhile advantages which, in the writer's opinion, would easily justify its installation, namely:

1. If the heat-exchanger be placed as near as possible to the condensing unit, it will bring about an increase in the capacity of the refrigerant lines due to the decrease in the weight of refrigerant which must be circulated.

2. It assures dry suction gas at the compressor and allows a closer adjustment of the superheat to be maintained at the expansion-valve thermal-bulb. Thus, instead of having to waste coil capacity by a ten or twelve degree superheat requirement, as low as five degrees, or perhaps somewhat lower, would prove to be good practice, depending, of course, upon the sensitivity of the expansion valve in service.

Finally, as a matter of record, all of the tables herein mentioned and appearing, were compiled by the use of calculating machines and/or a five-place table of logarithms and copiously checked.

The net gain in refrigerating capacity with a liquid vapor heat exchanger, as shown by author's calculations, ranges from 9.51% to 0.33% depending on the condensing temperature and the suction temperature. Between these extremes lie many practical values ranging from 4% to 6% where a heat exchanger justifies its existence and pays its way.

TABLE 9.—VALUES OF "X" AS A FUNCTION OF HEAT-EXCHANGER LENGTH AND NET GAIN IN REFRIGERATION CAPACITY.
SUCTION TEMP. = 40F AND CONDENSING TEMP. = 105F

Length in Feet, L	Small Temperature Difference, F				
	1	5	10*	20	40
	Net Gain in Capacity from Heat Exchanger, %				
	5.20	4.68	4.13†	3.06	1.31
	Corresponding Values of "Y"				
	25.963	13.790	9.139‡	5.002	1.748
	X = L/Y				
10	.385	.725	1.085	1.999	5.721
20	.770	1.450	2.171	3.998	11.442
30	1.155	2.175	3.256	5.998	17.162
50	1.926	3.626	5.427	9.996	28.604
70	2.696	5.076	7.598	13.994	40.046
100	3.852	7.252	10.854	19.992	57.208
150	5.777	10.877	16.282	29.988	85.812
200	7.703	14.503	21.709	39.984	114.416
300	11.555	21.755	32.564	59.976	171.625

*Item 15, Table 4. †Item 13, Table 4. ‡Item 21, Table 4.

the line is decreased, the cross section area decreases more rapidly than the inside surface, resulting in an increase in the percentage of suction gas in contact with and sweeping the heat transfer service. However, overall pressure drop along

*See How to Determine Size and Cost of Freon Lines, by William Parkerson; Heating and Ventilating, October, 1940, page 17.

+4 F Dry Bulb; 90% Relative Humidity

JOHN J. WOOLFENDEN

Engineering Staff, Smith, Hinchman & Grylls, Inc., Architects and Engineers, Detroit, Mich.

ABSURD! Is it? Stop and think a bit. True, 4F is far below the dew point or, if you like it better, when speaking of below freezing conditions, the saturation point, of air which showed any reasonable amount of relative humidity at a temperature above freezing; but what of that?

Impossible? Not a bit, although it seems so, at first sight.

As a matter of fact, the temperature and relative humidity were those reported by the local station of the United States Weather Bureau, recently, in response to a request for the current temperature and humidity readings.

Had they read the instruments incorrectly, or were the instruments inaccurate? Not necessarily and very unlikely so.

How, then, can such a condition exist? Let us apply a little reasoning and analyze the situation.

In the first place, atmospheric conditions are not static; that is, considering barometric pressure, both dry bulb and wet bulb temperatures and wind velocity as the essential factors, it must be admitted that one or more of them are changing, not only from hour to hour, but perhaps even from minute to minute.

Consider the case of falling temperature and let us assume, for the sake of simplicity, that the air is perfectly still and without even circulatory currents. Perfectly still air never exists, in the open, but of that, more later. Now let us suppose that an observation is made and that the readings show a temperature of 35F, D.B. with a relative humidity of 60%. Let us further assume that the temperature drops down to 0F. At about 30.5F the air becomes saturated and from that temperature to 0F it remains saturated, parting with its excess moisture as the absolute moisture content decreases with the temperature.

We finish up at 0F with 100% relative humidity and an absolute moisture content of close to 0.48 grains per cubic foot.

Now let us suppose that the temperature starts to rise and the next observation shows a temperature of 5F, D.B. Unless, during the interval, the air has been able to absorb moisture, its absolute moisture content is still about 0.48 grains per cubic foot, but its relative humidity has decreased to about 78%, as its capacity for moisture has increased to about 0.61 grains per cubic foot.

Such a condition could, perhaps, be produced in the laboratory, although it would be quite a problem to eliminate the possibility of any moisture gain, whatever. In nature, in the open, the occurrence of such a phenomenon might not be impossible, but it would be improbable to the *n*th degree.

It is not impossible, however, that the moisture absorbed during the rise in dry bulb temperature might be less than that required to reach saturation, and hence the relative humidity would drop to less than 100%. Hence, it is not unreasonable that air at temperatures far below the dew-point corresponding to normal, above-freezing humidity may present the anomalous aspect of having a relative humidity of less than 100%, but, in the case of perfectly still air, only under conditions of rising temperature.

On this basis, if the air was at +4F with 90% relative humidity, since the corresponding dry bulb saturation temperature is approximately +2F, it follows that the dry bulb temperature must have previously been at least that low.

As a matter of fact, the Weather Bureau report obtained on this point showed a minimum of about 3.5F, D.B. and 3.0F, W.B., which corresponds to a relative humidity of very close to 90%.

To what is the discrepancy due? Probably very largely to the fact that our hypothesis was based upon perfectly still air, together with the fact that the effect of barometric reading has been entirely neglected. As a mater of fact, the Weather Bureau determinations showed a wind velocity of about 6 miles per hour—by no means a negligible quantity. Furthermore, the air is not homogeneous, but is of a decidedly stratified nature, and more or less admixture of the various strata of different temperatures and relative humidities is to be expected as a result of diffusion and of localized circulatory air currents, if not of wind.

Under such conditions, with the proportions of the mixture varying according to the whim of the air currents, relative humidities may either increase or decrease, regardless of whether the dry bulb temperature is decreasing or increasing and, before making definite predictions as to the effects of a temperature change upon the humidity, or vice versa, *all* the governing factors must be determined. It is certain, however, that relative humidities of less than 100% are possible and actually exist at air temperatures far below the dew-point corresponding to the relative humidity indicated by recent previous readings showing higher values in both dry and wet bulb temperatures.

Air Cleaning Application Solves Odd Dust Problem

A CHINCHILLA, the skin of which goes into the making of fabulously priced chinchilla fur coats, ordinarily is a soft-eyed, meek little creature resembling a pearly-gray squirrel.

But when a chinchilla takes a bath, it does so with such vigor and abandon that it *literally* makes the dust fly.

It was the pall of dust and hair thrown up by several hundred chinchillas at their baths which created an unusual dust control and air cleaning problem for George C. England, chinchilla breeder of Inglewood, Calif.

England operates a breeding and boarding farm for the high-priced fur bearers in two buildings equipped with air conditioning and dust control facilities. One is a two-story stucco building, 26 x 50 ft, with a full-size cage room occupying each of the two floors. Each room contains 45 wire cages, 3½ ft long by 3 ft wide and 3 ft high, in which a total of 150 to 160 animals per room are confined. The other building is a one-story wooden structure which houses 160 animals in 60 wire cages in a room 23 x 60 ft. An average of 450 to 500 animals are housed in the two structures.

The chinchillas bathe in rock dust. The dust is pulverized limestone obtained on specification from the Pacific Limestone Co. of Santa Cruz, Calif. It has a texture nearly of the smoothness of talcum powder and will float lightly in the air like talcum. Each morning when the pens are serviced, a tin pan about 15 in. in diameter and 4 in. deep, containing 2 lb of rock dust, is placed in each pen. Then the dust begins to fly in the pen rooms as the chinchillas, still wide awake from their nocturnal scampering about the cages, literally dive headlong into the pans.

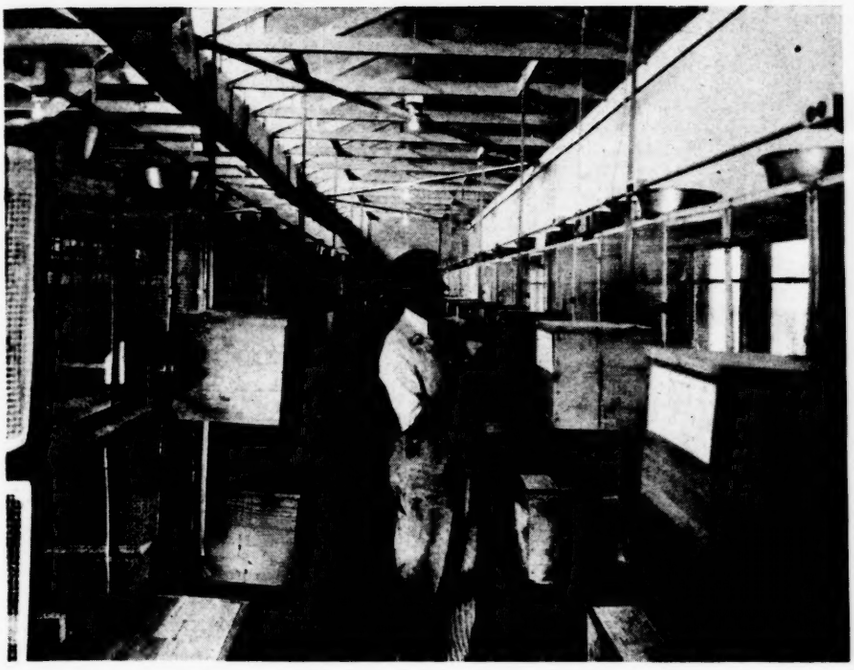
Rooms Filled with Dust

The vigorous actions of the chinchillas as they rolled, squirmed and scrambled about in the dust pans, accompanied by mouse-like squeals of pleasure, formerly created a dust problem of major proportions. The air in the pen rooms literally was filled with rock dust and hair dislodged from the bodies of the animals. The situation created a health menace to the chinchillas as well as to their attendants. It was necessary on some days to wait more than two hours before the atmosphere in the rooms had cleared sufficiently to permit attendants to enter with safety.

Before the present system for rapidly clearing the air of dust was installed, the farm operated a central refrigeration unit for keeping the breeding rooms at predetermined temperatures, and a recirculating duct system with cooling coil installations through which air was dispatched into the rooms by a fan mounted at one end of the duct. The recirculating arrangement did not permit the dust to settle but actually had the effect of keeping the air and dust in continuous suspension.

Noticing this, the air conditioning engineers who were called in for consultation recommended instal-

One of the pen rooms at the England Chinchilla Farm, in which 150 to 160 chinchillas are confined in wire cages. The chinchillas bathe in rock dust, which is placed in the tin pans (shown on top of cages). The large volume of dust and hair thrown into the air by the chinchillas in their vigorous bathing operations formerly created a serious dust problem.



Another pen room, showing proprietor George C. England holding a chinchilla on his arm. Air duct (upper left) brings filtered cooled air into the room through apertures in the duct's side.

lation of a bank of air filters in front of the circulating fan at the head of the duct system in each pen room so that all recirculated air would have to pass through the filters immediately after leaving the room, and the dust and hair thus be removed in the process.

Filters Solve Dust Problem

The filter system which was decided upon consists of six 20 x 20 x 2 in. Air-Maze Kleenflo permanent cleanable viscous-coated filters. A bank of six such filters is installed at the inlet to the fan which serves the duct system in each pen room. In the two-story building, the filter bank is installed in L-shaped arrangement, with four units—two above two—at the front of the duct, and two—one above one—at the side of the duct. In the one-story building the filters are installed in a square of six at the mouth of the duct, in front of the fan.

Each bank of six filters is capable of handling 4800 cfm. They are operated day and night. The exteriors are brushed off about every two weeks. In this time dust, hair and other impurities have accumulated in a layer about 1 in. thick.

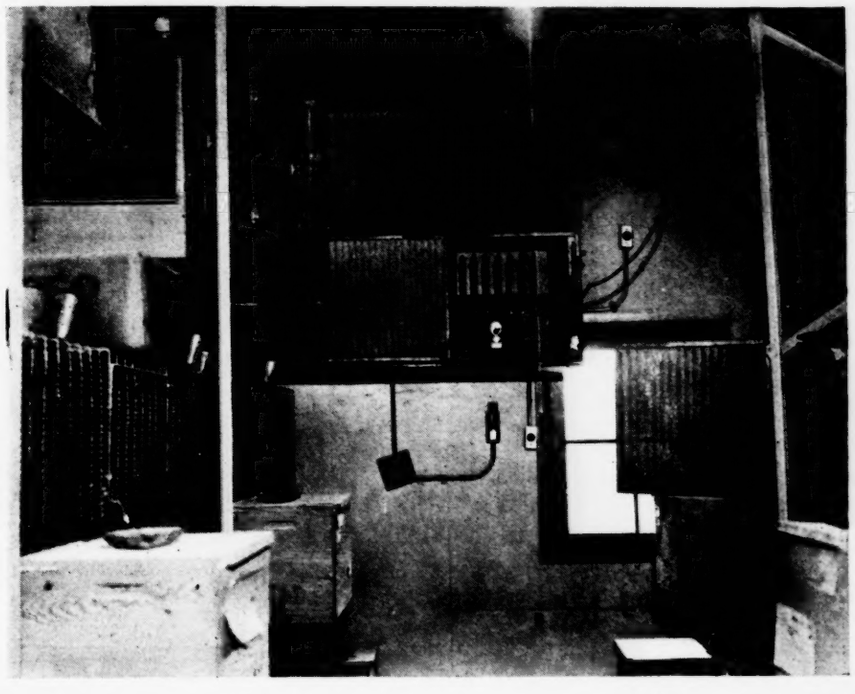
A Ray-O-Zone unit for purifying and sterilizing the air and neutralizing odor is installed inside the air duct in each building, facing the filter bank.

A metal duct, 2½ ft square, extends along the ceiling of each room in the two-story structure. The ducts run from the filter bank and fan installation at the back of the room and discharge through grilles at the farther end of the room.

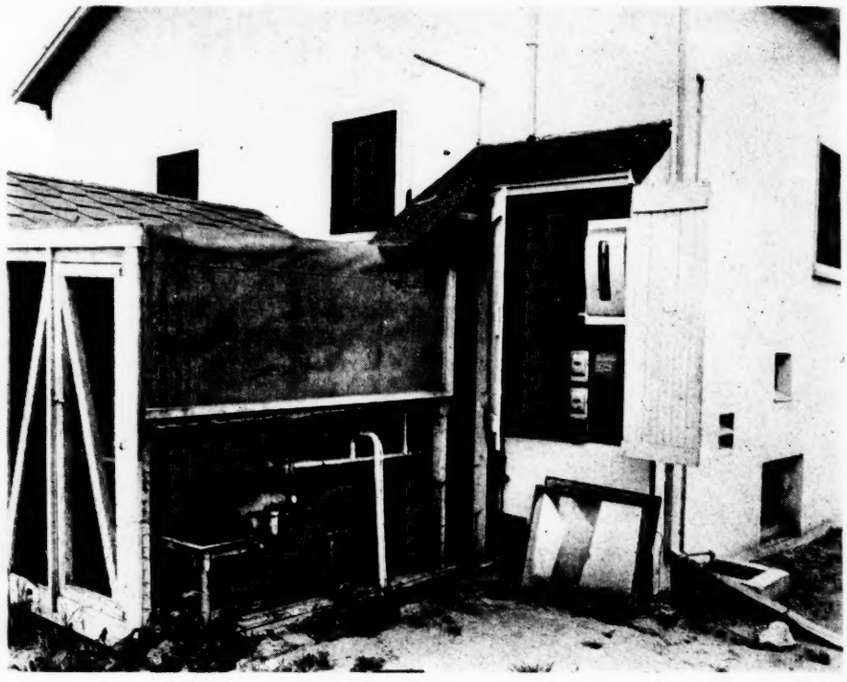
The supply duct in the one-story building is 12 in. wide and high and discharges air through 2-in. apertures in the side at 3-ft intervals. A 4,000 cfm blower serves the duct system.

Air Conditioned Gage Rooms

A cooling unit is installed in a lean-to behind the two-story building. Although this unit is capable of



How the dust problem was solved by installing Air-Maze Kleenflo viscous-coated filters at the intake of the duct and in front of the fan. There is a bank of six filters of this type in each of three pen rooms. Each filter bank can handle 4800 cfm. Since the filters were installed, the rooms are cleared of dust in three to five minutes, as compared with almost as many hours in the past.



Breeding rooms for chinchillas must be kept at 72F by thermostatic control, day and night. The cooling system shown consists of a Super Cold 10 hp compressor and a Trade-Wind blower.

bringing the inside temperature down to 40F, the temperature actually maintained lies between 70 and 75F and usually is held at 72F day and night by thermostatic control. Through more than 20 years of acclimatization in the temperate zone of North America, it is no longer necessary to keep the captive chinchillas at the below zero temperatures prevalent in their native habitat in the 14,000-ft elevations of the Chilean Andes. They thrive admirably now in approximately the same temperatures which human beings find comfortable.

In the cooling system which serves both buildings is a 10 hp Type S Super-Cold compressor unit, using methyl chloride as refrigerant. It is fitted with three lines for distributing coolant to air-fin cooling coils installed behind the filters, one coil in each of the three pen rooms. A Trade-Wind squirrel cage blower, which operates on the compressor only, is set up adjacent to the cooling machinery.

Before the filters were installed, from two to three hours elapsed after the morning bathing period before the air in the rooms had cleared and the dust settled. During that period the atmosphere was so heavily laden with hair and dust that breathing it was decidedly objectionable and actually dangerous.

Air Cleaned in 5 Minutes

With the 3 to 4 minute air changes of the present filtering system, the rooms are quickly cleared of dust and hair and other impurities and the air is maintained in a clean condition continuously. The filters are reported to clear the air in from three to five minutes after bathing, as compared with several hours under the former system.

Each of the present systems circulates 4,000 cfm of which approximately 80% is recirculated. Each of the 26 x 50 ft pen rooms in the two-story building has 10 ft ceilings and contents of 13,000 cu ft, while for the 23 x 60 ft room in the one-story frame building the ceiling is 12 ft and volume is 16,560 cu ft.

The two-story building—which once housed an incubator room on England's poultry farm — is insulated with 1 in. of Celotex on the ceiling. The one-story structure—a reconverted chicken-feed storage building—has 2 in. of Celotex on the ceiling. Sidewalls in either building have no insulation.

Wall mounted gas-fired unit heaters are installed in each building for heating on exceptionally cool days, because chinchillas at birth are unable to endure temperatures below 60F.

The chinchillas were fed tomato juice and raisins in the pre-rationing days when such items could still be obtained in sufficient quantities. Grapefruit is a popular food now and the little rodents gnaw a grapefruit down to a tissue-thin rind. Among other items in their wartime diet are pellets compounded of a mixture of various cereals; and peanuts, walnuts, alfalfa hay, prunes and a limited amount of raisins.

Chinchillas Worth $1600 Pair

The England Chinchilla Farm is a breeding and boarding establishment. England himself owns outright only ten pairs of the 480 animals which were on hand in March. The others are the property of various persons in Southern California who pay $5 a month per pair boarding fee. England's facilities in the form of buildings and equipment represent an investment of approximately $15,000, exclusive of the value of his personally owned breeding animals. He switched from poultry raising to chinchilla breeding about four years ago.

A pair of chinchillas (male and female) has an average value of $1200 to $1600. While there are no definite market quotations available at this time, the above figure is based on England's statement that he " . . . would not sell a pair for less than that amount." The 480 animals in the inventory of the

(Concluded on page 90)

How to Design Exhaust Hoods

By J. M. DALLA VALLE

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Part 10—Grille-Type Openings Under Suction

Openings discussed in Parts 5 to 8 are adapted to fixed operations. Grille-type openings act as combined local and general exhaust, and find their greatest application in operations where the production of dust or fume is caused by large movable objects, such as foundry castings. These openings, to be effective, must have velocity characteristics covering as large an area as possible. Grilles should be of sufficient size to perform removal of the air-borne contaminants in question. Operations productive of a given dust, fume, or gas should be placed close to the grille in order to obtain best results.

Usually, grille-type openings are employed in connection with exhausted hoppers. However, lateral grilles are common and to be found in many industries. Little is known regarding the effect of grilles on the velocity contour distribution. The air velocity at the opening is easily determined by the formula[23]:

$$V = \frac{2Q}{A + a} \qquad (32)$$

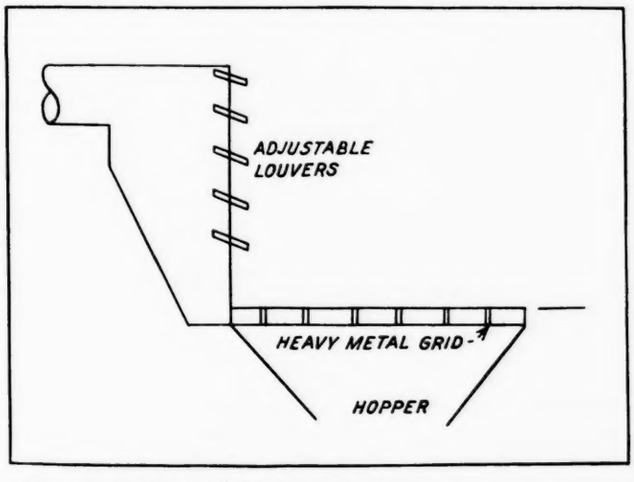
where V = opening velocity at the face of the grille in feet per minute,
Q = air volume handled in cfm,
A = total gross area of the grille in square feet, and
a = area of an interstice in square feet.

[23] L. E. Davies, Measurement of Air through Registers and Grilles, Trans. Amer. Soc. of Htg. & Vent. Eng., 39:373-394.

Foundry Shake-Out Exhausts

Remarkable progress has been made in controlling the foundry dust hazard. One of the serious occupational disease hazards encountered in this industry is dust arising from foundry shake-outs. The problem in this case is to have means available for eliminating the dust during shake-out of molds containing fresh castings. The usual process employed is to knock the flasks containing the mold and castings with sledge hammers to pry them loose. In some instances, this is done in places known as shake-out dumps, but more often it is done wherever the casting happens to be. Large castings containing considerable hard core work present serious difficulties and frequently cannot be brought under the control of an exhaust system. The worker is in such close contact with the dusty atmosphere as to cause serious exposure. In addition, this type of work is not generally isolated, and gives rise to a very general exposure which may involve all workers employed in the foundry.

A typical system used to exhaust foundry shake-out operations is shown in Fig. 80. This system is adapted to the handling of small parts, although it may be used for single castings of considerable size. The exhaust slots shown in the figure are adjustable and should be regulated to produce the requisite amount of air at the working area, so as to control the dust produced. The slots should be spaced at



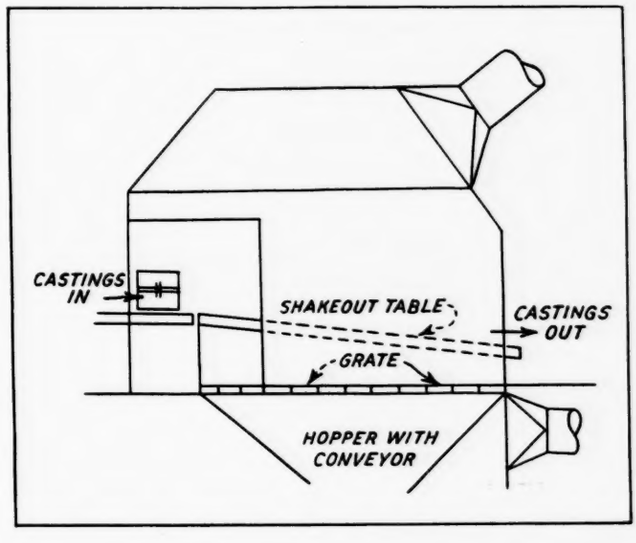


Fig. 80 (Left) and 81 (Right) Exhaust arrangements for foundry shake-out.

such intervals as to produce a velocity of at least 300 feet per minute at the edge of the grate. The slot velocities should preferably not exceed 700 feet per minute, but the duct velocities should not go below 4000 feet per minute in order to prevent any settling of the dust collected.

Other forms of shake-out employ lateral exhaust or totally enclosed automatic shaking devices, as in Fig. 81. Lateral exhausts require 300-400 cu ft of air per square foot of gross grate area. Automatic shaking equipment is closed during operation, the exhaust being used only to clear compartments of dust after shaking. Parts are moved into and from automatic shakers by conveyor belts.

Exhausts Used for Welding

In many instances welding and cutting of steel parts by flame offer difficulties not easily surmountable. This is due to the shape of the welded or cut material, which is often cumbersome and must be handled *in situ*. Welding is generally carried out in booths, ventilated through floor grilles. In some instances flexible hose connections are available and moved near the object welded or cut by the operator. This type of ventilation procedure is analogous to that used in granite cutting, elsewhere described. Opening velocities should be 200 feet per minute.[24]

In addition to booths, special vertical grillework provided with exhaust is used. This type of ventilation, which is sectioned, usually does not extend more than 2 feet above floor level and requires large quantities of air to be handled. Such grillework, designed to meet the needs of a particular operation, utilizes from 200 to 300 cubic feet per minute per square foot of gross area. All work is carried out as near the grille as possible.

Where local exhaust is used, the hoods should be provided with opening velocities of 200 feet per minute.

Booths are generally used for oxy-acetylene cutting, although in many plants welding is also done in these places. The booths are provided with either upward or downward type ventilation (usually the latter), and sufficient air is used to provide from 2 to 4 air changes per minute. Canvas draw curtains are employed over the front or entrance to the booth so that air inlets need not be provided for such booths.

[24]Philip Drinker, Henry Warren, and Richard Page, 1935. Electric Welding, III, Prevention of the Respiratory Hazard. Journal of Industrial Hygiene & Toxicology, 17;133-137.

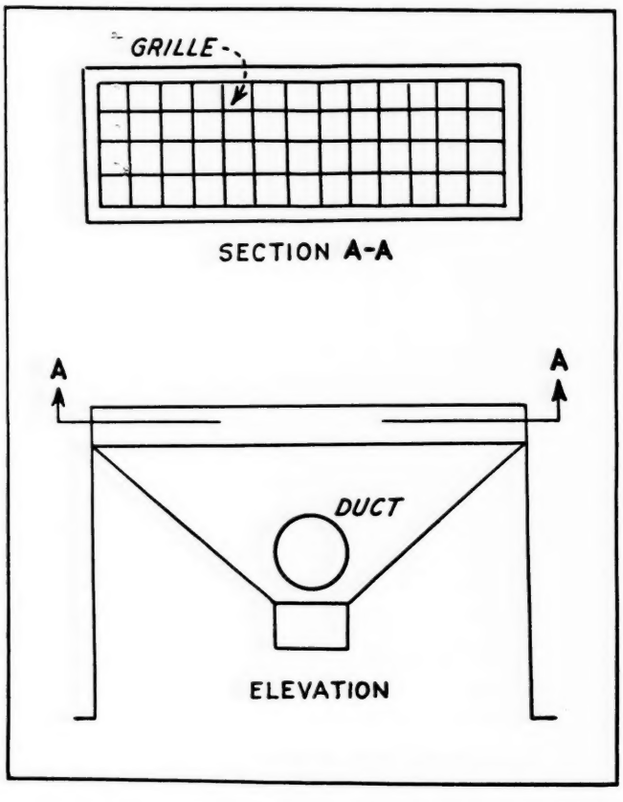


Fig. 82. Grille work and exhaust for small table.

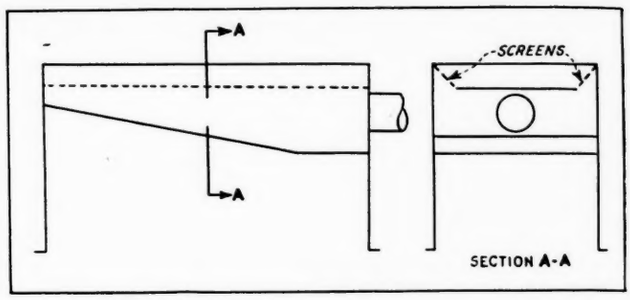


Fig. 83. Suggested design for controlling dust generated by portable disc grinders and polishers or for movable belt-type polishers.

Exhaust Tables

Exhaust tables consisting of grillework of various sizes are common practice in the lead storage battery industry. These are used in burning plate groups, and inserting separators. The oxide dust drops into the hopper where the accumulation of larger particles may be removed at regular intervals. A typical design is illustrated in Fig. 82. The fumes are conveyed through the duct system to a suitable point of collection.

Air volumes for grille tables range from 200 to 300 cu ft per square foot of gross grille surface.

Fig. 83 shows a suggested design for controlling dust generated by portable disc grinders and polishers or for movable belt-type polishers. The object to be ground is mounted lengthwise on the table and supported by means of a wire. Air is exhausted through the screens into a plenum chamber. The chief difficulty encountered in these operations is that due to the windage created by the moving disc or felt. In the case of the former, good results are obtained by flanging one side of the booth to a height of one or two feet. Belt polishers are harder to handle and therefore require more ventilation. From 300 to 500 cfm are required for every square foot of bench area to handle the dust generated.

(Part 11 of Mr. Dalla Valle's series will be devoted to Hood Entrance Losses.)

WASHINGTON NEWS

Summarized by Loring F. Overman. End of Metal Shortage in Sight; Heat Control Program Has Approval; F-12 Restrictions Further Tightened.

Often it is the minor eddies around the Washington whirlpool that first signal a change in the direction of flow of the national stream.

As they affect the heating, ventilating and air-conditioning industry, these eddies indicate that the leveling-off stage of the materials program has been reached; that new over-all restrictive regulations are unlikely, and that the back-to-civilian-production trend will be noted at a fairly early date.

Recent changes in Controlled Materials Plan regulations simplify the methods whereby small users may secure increased quantities of steel. Other CMP changes release moderate quantities of copper and aluminum for special purposes. Half a dozen WPB orders have been amended to ease restrictions on specific types of production, or to append production schedules authorizing construction, on a quota basis, of machinery, repair parts and a host of small but badly needed consumer items.

Although Washington is famous (perhaps infamous) for mental versatility involving political expediency, it is nevertheless significant to observe a new kind of about-facing under way. Scores of war agency executives—many of them loaned to government by private industry for the duration—have added a mental second shift to their personal schedules. They devote a full day to the immediate problems of war; a second shift to the equally puzzling problem of what happens to industry when the fall of Germany causes cancellation of some 30 or 40 billion dollars a year in war contracts—and what happens when defeat of Japan cuts war expenditures to a mere billion or billion and a half a month.

While the main responsibility for answering these questions lies with the Baruch's, the Byrnes', the Biddles and many others struggling *full time* with problems of contract cancellation and industry reconversion, the double-shift war agency executives are in a position to cushion the shock somewhat by revising WPB orders to dole out surplus materials to industry as rapidly as they are released by shifts in the military program.

Although drastic shortages continue in some fields—notably tires, petroleum, coal, lumber and containers of all types—the metals most important to the heating, ventilating and air-conditioning industry appear to be reaching the surplus stage.

Heating Controls Program

Typical of the changing supply situation is the decision of the WPB Program Bureau to authorize the Office of Civilian Requirements to approve the construction of 635,000 automatic heat control instruments in which approximately 400 tons of copper will be required.

The program calls for the construction of 600,000 domestic type barometric dampers; 15,000 commercial type barometric dampers; 5000 sets of domestic outside-inside thermostats with motor linkage, valves, relays and transformers and 15,000 commercial sets of the same type.

While the program has been authorized by the Program Bureau, it still awaits the approval of the WPB Requirements Committee. Many who have watched the ups and downs of the program since it originated in the Plumbing and Heating Division more than a year ago are keeping "fingers crossed" as the requirements estimate approaches what should be the final hurdle.

Their concern is due to the fact that on several occasions the program has bumped into unexpected resistance in official quarters, usually when it appeared to be in the clear and awaiting only a final okeh. As is usual in Washington when last-minute obstacles appear with any degree of consistency, proponents of the controls program began wondering whether the stumbling blocks were being "inspired" by some opposing force. In any event, those favoring automatic temperature control will breathe easier when and if the WPB Requirements Committee affixes its expected okeh.

Field to Allot Burners

Another example of the loosening of Washington reins is the proposed amendment to Limitation Order L-74 to permit WPB field offices to process applications for oil burners held in dealer's stocks. Applications for industrial burners will still clear through the Washington office of the WPB Plumbing and Heating Division, which will also handle allocations to dealers.

The Plumbing and Heating Division, incidentally, has moved again—is now back in its original quarters at Temporary Building E. This move also has its significance—indicating that Washington's sprawling agencies are being recalled from their widely flung quarters in rented buildings as contracting staffs in other agencies make room in government-owned structures.

Repair Materials Released

CMP Regulation 9A, issued November 25, makes another eddy in the supply pool by outlining conditions under which persons in the business of making repairs may buy steel, copper and aluminum. The regulation provides that anyone in the business of making repairs, including repair shops owned by the person for whom the repairs are to be made, is eligible. Says the Regulation:

"Each calendar quarter a repairman may buy, under this regulation, up to 20 tons of carbon and alloy steel, a total of 500 pounds of copper and copper base alloy brass mill and foundry products, and 200 pounds of aluminum (in the forms listed in Schedule 1, appended to the order). In addition, refrigeration repairmen, *** may buy $150 worth of copper wire, or one-eighth of what they used in making repairs in 1941 *** whichever is more. ***"

The regulation states that if additional amounts are required, the War Production Board may authorize repairmen who do work primarily of an industrial nature to buy up to 2000 pounds of copper wire and a total of 2000 pounds of copper and copper base alloy brass mill and foundry products, on an AA-2 rating. A letter of application is all that is required to qualify under this provision.

Additional amounts of controlled materials for repair purposes may

be secured by repairmen by filing CMP-4B applications with the War Production Board.

Oil Stocks at 60% Level

Still on the shortage list is fuel oil, stocks of which were at less than 60 percent of normal during the week of November 18, according to figures issued by the American Petroleum Institute. Oil stocks were reported at 59.7 per cent of normal, compared with the previous week's position, 56.7 per cent. Residual fuel oil stocks decreased from 79.9 to 78.3 per cent of normal.

Helping to maintain supplies close to programmed levels was the continued movement of more than 400,000 barrels daily by pipeline. The Big Inch is reported rapidly nearing capacity flow, having delivered 288,000 barrels on November 15. Pipeline deliveries into the East Coast area averaged 417,650 barrels per day during the week ending November 13, with tank car deliveries at 758,131.

Freon Further Restricted

Continuance of the Army's insecticide program and the peak demands of the ship-board refrigeration program are considered responsible for further tightening of restrictions on the delivery of Freon-12, effected by a complete revision of Conservation Order M-28.

In addition to previous prohibition on delivery of Freon for air-conditioning systems for comfort cooling and a few types of refrigerating systems, a new restriction prohibits deliveries until April 1, 1944, for any other system except where it is operated under one or more of the following conditions:

1. Where an air-cooled condenser is used and the ambient temperature is 110 degrees F or higher; or
2. Where the saturated refrigerant temperature corresponding to the suction pressure is less than minus 10 degrees F; or
3. Where aluminum or magnesium alloys or rubber have been used in construction of the system and come in contact with the refrigerant, and are not easily replaceable; or
4. Where the system is for use aboard ship or outside of the continental United States by the Army, Navy, Maritime Commission or War Shipping Administration; or
5. Where the total operating charge required to operate the system is ten (10) pounds or less of F-12 gas and the system was in operation on November 12, 1943, and is used for food preservation; or
6. Where the use of Group 2 or Group 3 refrigerants, as defined in the American Standard Safety Code for Mechanical Refrigeration, ASRE Circular No. 15, ASA-B9-1939, as approved by the American Standards Association April 20, 1939, is prohibited by the Code.

The foregoing restrictions apply not only to systems used for ordinary civilian systems, but also to those owned, operated, or used within the continental United States by the Army, Navy, Maritime Commission or War Shipping Administration, including Post exchanges and ships service stores, other than those used aboard ships.

Completion of a new Freon producing plant in February is expected to ease the supply situation and permit easing of the present emergency restrictions.

Industrial Instruments

Two important changes were made during the month in Limitation Order L-272 (Industrial Type Instruments, Control Valves and Regulators). Addition of Schedule VII to the order eliminates a number of sizes, types and special features of industrial and special-purpose thermometers. The action is expected to conserve critical man-hours and increase the quantity output of industrial thermometers as much as 10 per cent. The standardization will also result in minor savings in materials.

The schedule restricts scale ranges in industrial thermometers between minus 40 degrees and plus 950 degrees F to the following list:

0–plus 60
0–plus 100
minus 10–plus 110 (for 5-inch scale only)
minus 40–plus 110
0–plus 160
plus 30–plus 180
plus 120–plus 220
plus 30–plus 240
plus 170–plus 270
plus 30–plus 300
plus 200–plus 360
plus 50–plus 400
plus 200–plus 500 (for 5-inch scale only)
plus 100–plus 550
plus 150–plus 750
plus 400–plus 850
plus 200–plus 950

The schedule also provides that cases and case fronts shall not be made of copper or copper alloy other than copper tubing, copper alloy tubing, or cylindrical extruded shapes.

Amended Schedule IV to Order L-272 was revised November 12, changing the definition of indicating dial pressure gauges to make it clear that it applies to pressure instruments in either round or square cases.

The amended schedule permits some types and features of gauges to be manufactured for special purposes. These exceptions represent special types of gauges which are manufactured as "specialties" by instrument manufacturers who are not generally considered to be a part of the pressure gauge industry, the Radio and Radar Division of WPB said. The few pressure indicators which they produce are designed for special applications and are generally used in conjunction with other types of industrial instruments. Typical of these added exceptions are automotive type gauges, gauges for stationary combustion engines and special accuracy gauges of 12-inch or greater dial diameters.

Additional ranges in the 3½-inch and 2½-inch gauge sizes were permitted. Fire-fighting equipment uses both pressure and vacuum gauges, and the amended schedule permits the simplified production of these gauges in one instrument.

The restriction on brass cases was modified to permit them for the 4½-inch and 6-inch gauges manufactured with a solid front for use with compressed gases such as hydrogen, oxygen, nitrogen, helium, acetylene and carbon dioxide. This was permitted as a safety precaution.

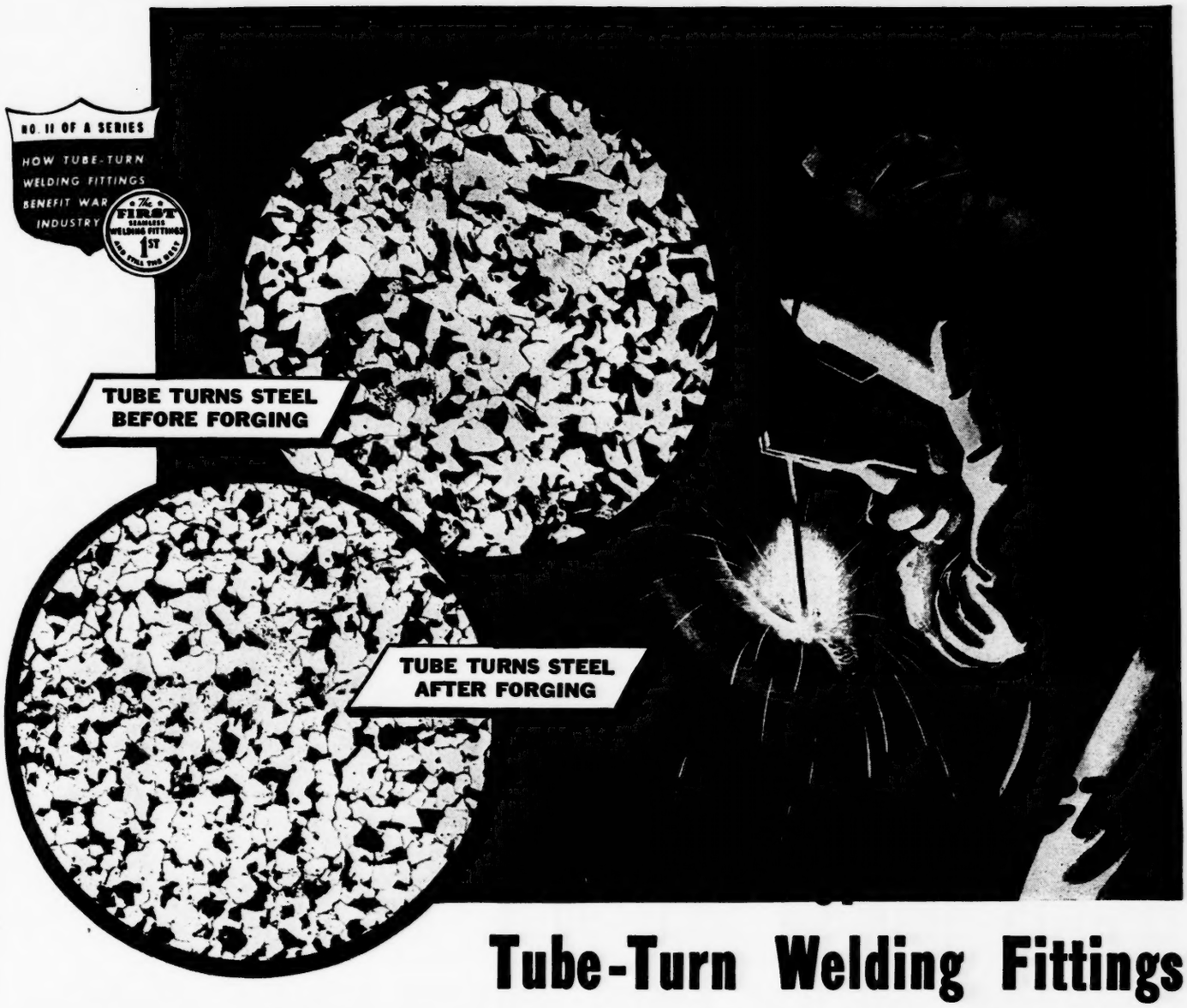
New Burners Approved

Amendment 87 to the fuel rationing order, effective November 11, provided that fuel oil rations will be issued for use in new fuel oil furnaces, provided the new equipment replaces worn-out burners and results in increased efficiency. Another section of the amendment brings the fuel oil regulations into conformity with PAW and WPB actions suspending the policy requiring conversion of commercial and industrial equipment from heavy fuel oil to an alternate fuel.

Critical Products Deadline

Direction No. 2 to Priorities Regulation 18 requires that orders for several products of interest to the heating and ventilating industry, being of a critical nature, must be filed before the first of the year if delivery is to be made during the first half of 1944. Orders requiring delivery of such items during the third and fourth quarters of 1944 must be placed before March 1, 1944. The items are divided into two groups, Group A covering internal combustion engines and accessories; Group B including:

Anti-friction bearings; steel boilers, pressure 100 pounds or more per square inch; compressors; diesel engines; fluid power systems; heat exchangers; high-pressure blowers; industrial type wet well batteries; motors and generators; motor controls; steam turbines; turbine generators; control valves; high pressure valves limited to plug valves, steam valves and safety and relief valves; pumps, industrial and marine.


NO. II OF A SERIES
HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY
The FIRST SEAMLESS WELDING FITTINGS 1ST
TUBE TURNS STEEL BEFORE FORGING
TUBE TURNS STEEL AFTER FORGING

Tube-Turn Welding Fittings prolongs piping service under wartime demands!

URGENT three-shift war plant schedules demand uninterrupted piping service—yet they impose triple duty on vital piping arteries. Fittings and joints bear the brunt of this wear and strain.

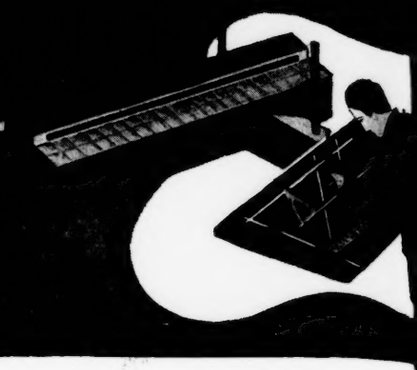
Tube Turns' exclusive manufacturing process actually improves on the top quality seamless steel tubing from which these fittings are forged. Proof lies in the 100X photomicrographs shown here. The finer grain quality in the Tube Turns metal structure guarantees the added strength and greater resistance to wear and corrosion. Even *better* proof lies in the long, unfailing service Tube-Turn Welding Fittings are rendering in thousands of war plants today.

TUBE TURNS (Inc.) Louisville, Ky. ***Branch Offices:*** New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Houston, San Francisco, Seattle. . . . . ***Distributors located in principal cities.***

TUBE-TURN

Welding Fittings and Flanges

REVIEWS



FORCED WARM AIR HEATING

"Pressure Losses in Registers and Stackheads in Forced Warm-Air Heating," by Alonzo P. Kratz and Seichi Konzo; Bulletin 342, Engineering Experiment Station, University of Illinois, Urbana, Ill. 6 x 9 in., 60 pages.

The advent of the forced air heating system for winter heating and summer cooling, with the accompanying use of high air velocities, has made it necessary that more attention be given to the direction of the air stream and the distribution of the air in the room.

The main objectives of the investigation described in this bulletin were (1) to study the pressure gradients existing in the air stream on both sides of a register, and to derive a significant index for evaluating the pressure loss of the register; (2) to determine the effect on the pressure loss of varying the size of borders on registers; (3) to determine pressure losses for air outlets of various types; (4) to determine the pressure losses with registers attached either to the end of a straight duct, or to a stackhead; (5) to determine the effect on pressure loss of placing turning vanes in the stackhead; (6) to determine the effect on pressure loss of varying the relative sizes of registers and stackheads.

Commercial stock registers were used for most of these tests, and the measurements of pressure loss were made primarily with the object of establishing design factors by obtaining general relationships between pressure losses and various features of construction. Such design factors would be useful in the development of registers characterized by minimum pressure losses.

APPROXIMATE MATHEMATICAL SOLUTION

"The Solution of Simultaneous Linear Equations by Approximation Method," by L. T. Wright, Jr. Six-page Bulletin No. 31 of the Cornell University Engineering Experiment Station, Ithaca, N. Y.

At present simultaneous linear equations are solved by a laborious method, particularly if the group consists of, say, four or five unknowns.

The procedure suggested by Professor Wright is to develop tables of approximate values to satisfy conditions of the equations. Values are ultimately determined which give very close approximations and these are certainly accurate enough to be used in engineering work which normally is controlled by factors that may alter results obtained through pure mathematics.

The author compares results obtained by his method with those obtained by conventional procedure.

PIPE AND TUBE BENDING

An 8½ x 11 in. paper bound, 80-page handbook entitled "Pipe & Tube Bending Handbook," and published by the Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y. Available on request on company letterhead.

This booklet, which is profusely illustrated, very well done, and most comprehensive, gives information on the proper methods of handling bending of copper and brass pipe and tubing. Among the chapters are those on use of filling materials, pipe and tube bending methods and devices, typical tube bending material describing and illustrating various tools on the market, wrinkle-bending of non-ferrous pipe and tubing, and how to build a wrinkle bending rig, all of which occupies the first half of the book. The second half is devoted to data including those on physical properties of copper pipe, dimensional data, pipe sizing tables for cold water, and data on seamless tubes of copper and brass.

GAS AIR CONDITIONING

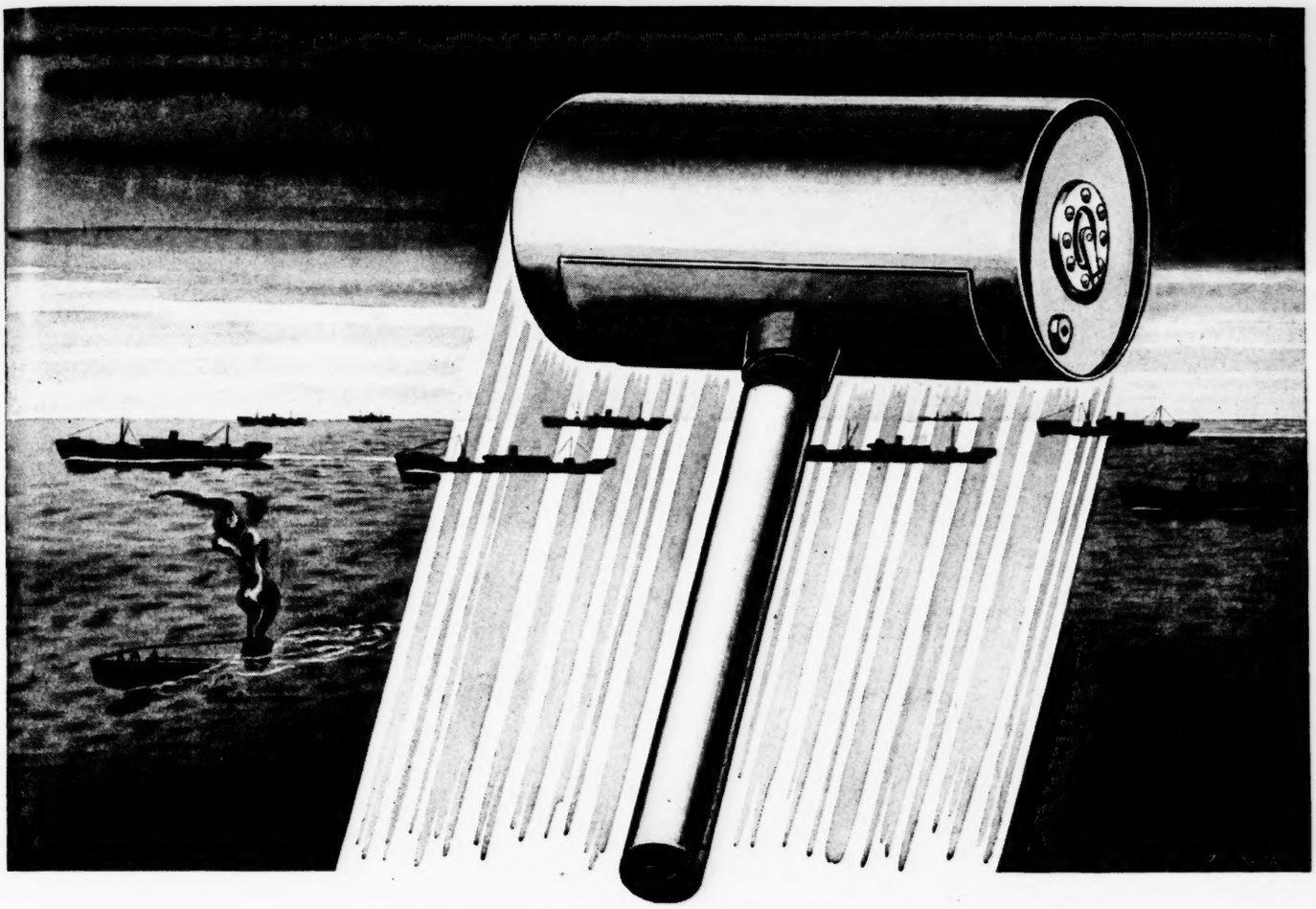
"Summer Air Conditioning," Research Bulletin No. 18, conducted under supervision of the American Gas Association Technical Advisory Committee on Gas Summer Air Conditioning Research, consisting of the following: G. E. May, Chairman, New Orleans Public Service, Inc.; L. Ourusoff, Washington Gas Light Co.; W. F. Friend, Ebasco Service, Inc.; C. A. McKinney, United Gas Corp.; John deB. Shepard, Consolidated Gas Electric Light and Power Co. of Baltimore; H. L. Warren, Southern California Gas Co.; and Eugene D. Milener, American Gas Association. Standard size, 134 pages, flexible binding, containing 61 illustrations and 28 tables. Price $2.50 plus postage.

The Technical Advisory Committee on Gas Summer Air Conditioning Research of the American Gas Association has just issued through the A.G.A. Testing Laboratory, research bulletin No. 18, entitled "Gas Summer Air Conditioning" — a comprehensive 134-page printed bulletin intended primarily for gas utility engineers and executives. The bulletin is a condensation of test results and data presented to the committee and interested manufacturers in eleven progress reports aggregating about 950 pages.

The bulletin is divided into four parts, the first being a summary of results and conclusions, the second part devoted to equipment, and the third to testing procedure and resulting data. The fourth part, prepared by John deB. Shepard, Consolidated Gas Electric Light and Power Company of Baltimore, and entitled "General Air Conditioning Technology," is, in reality, a brief textbook on air conditioning in general, and prepared primarily, it would seem, for gas utility engineers not heretofore acquainted with the subject. Part 4 is unusually well prepared and is one of the best brief discussions of the general subject that this reviewer has seen.

Gas summer air conditioning equipment of various manufacturers is discussed throughout the bulletin but mainly the information is devoted to equipment by Servel, Williams Automatic, and Bryant, although lesser attention is paid to industrial equipment made by Surface Combustion, Pittsburgh Lectrodryer, and others.

The bulletin should certainly accomplish its objective, which was to secure facts about contemporary equipment to stimulate activity in the subject, to provide data to assist manufacturers, and to aid in postwar planning and subsequent action. To those engineers accustomed to thinking of summer air conditioning in terms of electric equipment, this bulletin may come somewhat as a shock since the data and information on gas equipment presented in it are most impressive.



U-boat killers

They're called ash-cans. It's an apt name. There isn't anything spectacular about these sheet-steel drums, but they are packed with TNT, and when they go off near a U-boat they often stave in its plates, bringing its career to a sudden end.

There is a tremendous amount of sheet steel being used in preparing these depth charges, and a lot more may be needed before Hitler's U-boats are finally licked. Bethlehem Steel Company is producing substantial tonnages of sheet steel for use in depth charges. We are turning out steel sheets by the thousands of tons for dozens of military uses, such as ammunition cases, wind-shields for shells, bomb fins, field kitchens, truck and tank parts, air ducts for naval vessels—as well as for essential uses on the home front.

★ ***BETHLEHEM STEEL SHEETS*** ★ ★

BETHLEHEM STEEL

★ ★

REFRIGERATION AND AIR CONDITIONING

"How Air Conditioning has Advanced Refrigeration," by Willis H. Carrier. Published in Mechanical Engineering, May, 1943, by the American Society of Mechanical Engineers.

The author of the above paper, presented originally at a recent meeting of the West Virginia section of the ASME, needs no introduction to heating and air conditioning engineers. In his usual thorough and lucid style, he traces a graphic history of the refrigeration art, and shows the influence which the comparatively new air conditioning industry has had in bringing about advances in refrigeration.

Cited as the three greatest advances in refrigeration since the inventions of Lindy less than 75 years ago are: (1) the development of a series of new and important refrigerants, including low-pressure refrigerants; (2) the development of a low-pressure system of refrigeration, involving centrifugal compression; and (3) improvements in performance and capacity of automatically controlled reciprocating compressors adapted to the new refrigerants.

FLANGE AND FITTING STANDARD

"Pressure-Temperature Ratings for Steel Pipe Flanges, Flange Fittings, and Valves (B165-1943)". Published by American Standards Association, 29 W. 39th St., New York, N. Y. Price, 25c.

Higher pressures have been authorized for steel flanges, flanged fittings, and valves used in water, steam, and on pipe lines in an American war standard approved recently by the American Standards Association. The new ratings are revisions of Tables 6 through 11 of the American Standard for Steel Pipe Flanges and Flanged Fittings (B16e-1939). This new revised standard gives detailed information concerning calculation results and materials, and also contains four tables of pressure-temperature ratings with charts.

Copies of the new war standard are available from the American Standards Association at 25 cents each.

HUMIDITY AND STATIC

"Static Electricity", by Francis B. Silsbee. National Bureau of Standards Circular C438, published by United States Government Printing Office, Washington, D. C. Price, 10 cents.

Static electricity is a source of fire hazard or mechanical trouble in many industrial processes and this circular discusses the nature and origin of such electrical charges together with various methods of mitigating the associated hazards. These methods include (a) grounding; (b) neutralization; and (c) humidifying, the latter being of special interest to heating, ventilating and air conditioning engineers. The author corrects the rather commonly-held belief that an increase in the amount of water vapor increases the conductivity of air, whereas actually there is a slight decrease, the benefits which come with humidification being due to increased conductivity of adsorbed moisture films on material surfaces. It is pointed out that although humidification is often of great benefit in eliminating the effects of static it is not a panacea. Certain industrial operations, for example, those involving hygroscopic powders and various processes in textile mills, must be performed in a dry atmosphere. Certain other operations, where the time factor required in the building-up of a film of moisture on the surface of a material is a limiting factor, reduce the effectiveness of humidification in allaying static. Paper or other sheet material unwinding rapidly from a dry roll is an example of this.

Circular is paper-covered, 36 pages, 6 x 9 in.

SPACE HEATER STANDARD

"Proposed Commercial Standard (Emergency) for Coal Burning Space Heaters." TS-3443. Published by the National Bureau of Standards, Washington, D. C.

Following adoption at the special conference on coal burning space heaters in Washington in February of this year, this proposed new standard is being circulated to producers, distributors, testing laboratories, and users. Surface-fired and magazine-feed flue-connected heaters with output rating up to 60,000 Btu per hr, using Chestnut size anthracite as a test fuel, are included in the scope.

A related standard TS-3442 gives a condensed record of the conference mentioned above at which the new standard was adopted.

BRIEF REVIEWS

CLIMATE AND WEATHER—The second edition of "An Introduction to Weather and Climate," by Glenn T. Trewartha, Professor of Geography, University of Wisconsin, has just appeared. This book, first published six years ago, has been revised to make available important new material on air masses and air mass analysis; revisions of the world climate systems, a rewritten section dealing with the elements, weather and climate, and the addition of ninety to one hundred new illustrations. Recommended for anyone with an interest in weather and climate, particularly for one approaching the subject from a student's standpoint. Size 6 x 9 in., 545 pages. Includes a number of outline maps and charts for plotting of data. Published by McGraw-Hill Book Company. Price, $4.00.

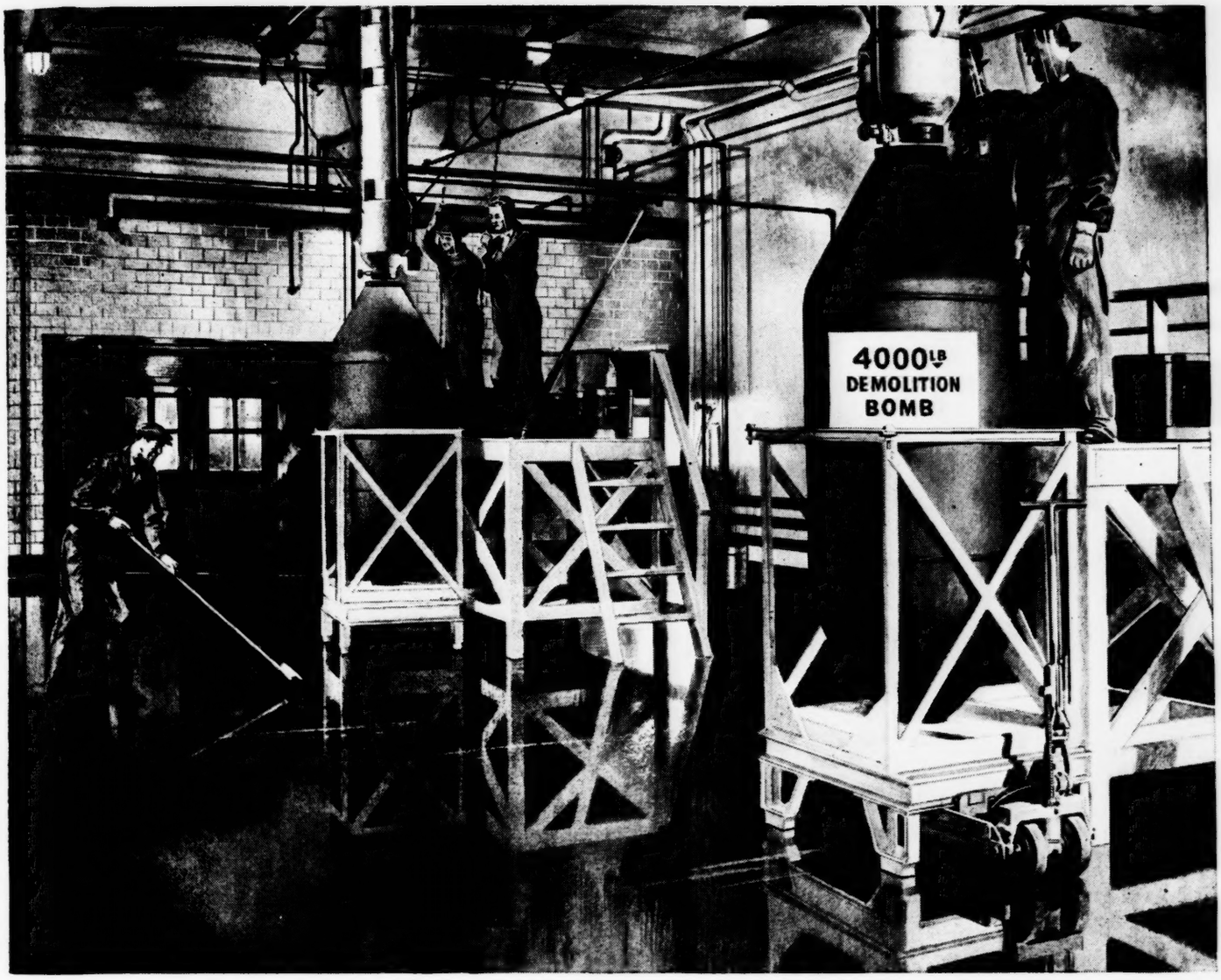
REFRIGERATION AND AIR CONDITIONING IN WAR AND PEACE. A 32-page illustrated booklet issued by the Air Conditioning and Refrigerating Machinery Association, Southern Building, Washington, D. C., to show how refrigeration and air conditioning is serving industry during the present war period and also its possibilities during the post-war period. While a large part of this booklet is devoted to the preservation of food, enough illustrations are cited to bring out how industry may be better served by refrigeration and air conditioning. This booklet contains a large number of photographic illustrations.

HEAT TRANSFER—Structural and heat-transfer properties of multiple box-girder plywood panels for walls, floors, and roofs. Report BMS99 of "Building Materials and Structures." Published by the National Bureau of Standards. Standard size, 25 pages. Obtainable from the Superintendent of Documents, Washington, D. C. Price 15c.

COMBUSTION—A 14-page booklet in French and titled "L'Equation Generalisee De Combustion," by Boleslaw Szczeniowski of the L'Ecole Polytechnique. The author gives a graphic method of solving his combustion equation and shows the chemical process that occurs in partial as well as complete combustion. The bulletin is an extract from the Revue Trimestrielle Canadienne of June, 1943.

COPPER—A standard size, single data sheet covering standard commercial wrought coppers and copper-base alloys, and giving the composition and forms generally available of the different types of coppers, plain brasses, leaded brasses, and bronzes. Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y.

COAL—Annual report of research and technologic work on coal, fiscal year 1942, designated as I.C. 7241. Published by the Bureau of Mines, Washington, D. C., 64 multilithed pages.



Why do they wax the floors in an ordnance plant?

THESE MEN ARE filling a 4000-lb. "block buster" with high explosive in the (censored) ordnance plant.

The floors of this plant are of waxed concrete and are polished every night. The walls of tile and high-gloss paint are kept shining clean. These precautions help prevent small particles of TNT from accumulating on the walls and floors.

As an additional safeguard against explosions, Dust-Stop Air Filters were installed in the air-conditioning system of the plant. These filters further reduce the hazard of explosive dusts by removing them from the air.

In scores of war plants

. . . Dust-Stops are today protecting workers and the products which they make. They guard delicately machined surfaces from the damage caused by grit and grime. They help assure the accuracy of bomb sights, portable radio transmitters, tank parts, and many other precision instruments and assemblies.

Low-price advantage

As original equipment for commercial and industrial installations, Dust-Stops cost only about 1¢ per CFM to install. Their replacement cost is less than 1/10th of 1¢ per CFM.

Dust-Stops may also be vacuum cleaned or gently rapped to remove excessive surface-dust accumulations. This process may be repeated once or twice to reduce maintenance costs still further.

Ask your regular supplier about Dust-Stops, made from materials now listed as non-critical. Or write for complete technical data to: *Owens-Corning Fiberglas Corporation, Toledo 1, Ohio. In Canada, Fiberglas Canada, Ltd., Oshawa, Ontario.*

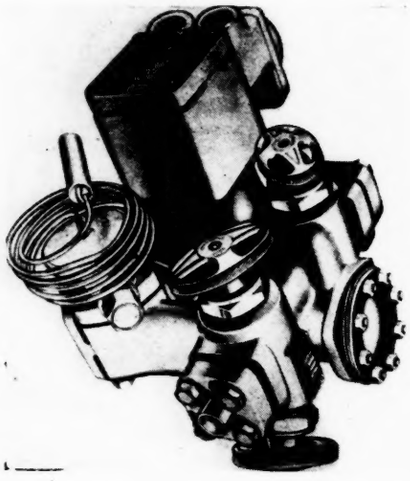
FIBERGLAS*

DUSTOP*

*T. M. Reg. U. S. Pat. Off.

AIR FILTERS

NEWS OF EQUIPMENT AND MATERIALS



Prefabricated Refrigerant Control Set

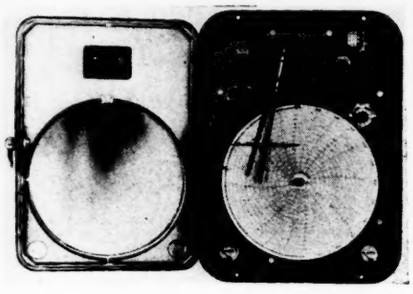
NAME—Navy type Q control valve manifold.
PURPOSE — A prefabricated automatic refrigerant control to replace built-up by-pass assemblies.
FEATURES — Device combines into one compact assembly a solenoid valve, thermostatic expansion valve, strainer, shut-off valves, hand expansion valve, flanged line connections, and a mounting bracket. Use of this device, worked out by Alco Valve Co. and the Henry Valve Co. in co-operation with the U. S. Navy Department, is intended to eliminate twenty joints or potential refrigerant leaks. Originally intended for use aboard ship, device also has other applications where its installation would be practicable and economical, particularly where vibration is present.
SIZES AND CAPACITIES—Made in a wide range of capacities, voltages, and line connections.
MADE BY — *Alco Valve Company, St. Louis 5, Mo.*

Electric Tachometer

NAME—Ideal electric tachometer.
PURPOSE—For measuring rotating speeds up to 5000 rpm.
FEATURES — Device is self-energized and said to be accurate to ± 1% of full scale deflection. Essentially it consists of a small generator coupled electrically to a meter.
SIZES AND CAPACITIES—Size of generator only 1⅝ in. diameter x 3¾ in., weight 20 ounces.
LITERATURE AVAILABLE—Catalog No. 50-001 covering 0 to 2500 rpm units and Catalog No. 50-002 covering 0 to 5000 rpm units.
MADE BY—*Ideal Commutator Dresser Co., Sycamore, Ill.*

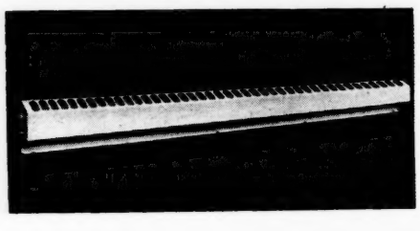
Convertible Controller

NAME—Bristol convertible free-vane controller.
PURPOSE—For automatically controlling temperature, fluid flow, liquid level, pressure, draft, humidity, pH value, and time cycles. This instrument uses the same free-vane principle as used in the company's previous models but is designed so that the user can convert from one type of control system to another. Certain refinements in design have been included. Offered in the following types: Monoset (on and off), Ampliset (throttling), Preset, Reset, and Magniset.
MADE BY—*The Bristol Company, Waterbury, Connecticut.*



Dunham OTS Convector

NAME—Dunham OTS convector.
PURPOSE—An adaptation of OTS heating element to deluxe enclosures and intended for such installations as those on shipboard where appearance is a major factor.
FEATURES—For features of element see description of OTS convector heating element last month. Casing is constructed of 18-gage metal with punched-in grille in sloping top. Casing is painted with gray paint chromate primer for protection.
SIZES AND CAPACITIES—In six lengths ranging from 18 to 72 in. and with capacities from 1995 to 8160 Btu per hr based on 1 lb steam and 65F entering air temperature.
LITERATURE AVAILABLE — Bulletin 620.
MADE BY—*C. A. Dunham Company, 450 E. Ohio St., Chicago 11, Ill.*



Temperature Control

NAME—Temp-Turb.
PURPOSE—Control of temperatures for airplanes; other applications expected in post-war period.
FEATURES — Air flowing through the assembly operates the device as a simple impulse turbine. The turbine blades are bi-metal and are not rigid. The direction of blade curvature is controlled by the temperature of the air flowing through. Shutters are closed when the temperature goes below the control point. The manufacturer claims that direct temperatures can be held to within + or — 5F if the source of heat is close to the control assembly.
SIZES AND CAPACITIES — The Temp-Turb control assembly comes in two general ratings. Group 1 with a rated flow of 2000 lb of air per hr at 200F and 20,000 ft altitude; group 2, 1000 lb of air per hr at 300F and 12,000 ft altitude.
MADE BY—*General Electric Company, Schenectady, N. Y.*

Metal-Plated Plastics

NAME—Metal plating of plastics.
PURPOSE—Metal plating of plastics is said to be permanent and will not crack or peel off in long service; conserves critical materials, reduces production costs, saves waste, prevents absorption of oils, solvents and moisture as well as increased heat resistance.
FEATURES—Plating is applied to plastics on convex or concave surfaces, convolutions, and corners. Can be used for plating, shielding, beautifying devices, and provide conductor and insulator in one unit. Both rigid and pliable types of plastic tubing and pipe fittings can be plated.
MADE BY—*Precision Paper Tube Company, Special Products Division, 2023 W. Charleston St., Chicago 47, Ill.*

Never mind "who done it"—pitch in and help get it down!

THIS IS YOUR UNCLE SAM talking—but I'm going to talk to you like a DUTCH uncle, to keep all of us from going broke.

Ever since the Axis hauled off and hit us when we weren't looking, prices have been nudging upwards. Not rising awfully fast, but RISING.

Most folks, having an average share of common sense, know rising prices are BAD for them and BAD for the country. So there's been a lot of finger pointing and hollering for the OTHER FELLOW to do something—QUICK.

The government's been yelled at, too. "DOGGONNIT," folks have said, "WHY doesn't the government keep prices down?"

Well, the government's done a lot. That's what price ceilings and wage controls are for—to keep prices down. Rationing helps, too.

But let me tell you this—we're *never* going to keep prices down just by leaning on the government and yelling for the OTHER FELLOW to mend his ways.

We've ALL got to help—EVERY LAST ONE OF US.

Sit down for a minute and think things over. Why are most people making more money today? It's because of the SAME cussed war that's killing and maiming some of the finest young folks this country ever produced.

So if anyone uses his extra money to buy things he's in no particular need of . . . if he bids against his neighbor for stuff that's hard to get and pushes prices up . . . well, sir, he's a WAR PROFITEER. That's an ugly name—but there's just no other name for it.

Now, if I know Americans, we're not going to do that kind of thing, once we've got our FACTS straight.

All right, then. Here are the seven rules we've got to follow as GOSPEL from now until this war is over. Not some of them—ALL of them. Not some of us—ALL OF US, farmers, businessmen, laborers, white-collar workers!

Buy only what you need. A patch on your pants is a badge of honor these days.

Keep your OWN prices DOWN. Don't ask higher prices—for your own labor, your own services, or goods you sell. Resist all pressure to force YOUR prices up!

Never pay a penny more than the ceiling price for ANYTHING. Don't buy rationed goods without giving up the right amount of coupons.

Pay your taxes willingly, no matter how stiff they get. This war's got to be paid for and *taxes are the cheapest way to do it.*

Pay off your old debts. Don't make any new ones.

Start a savings account and make regular deposits. Buy and keep up life insurance.

Buy War Bonds and hold on to them. Buy them with dimes and dollars it HURTS like blazes to do without.

Start making these sacrifices now—keep them up for the duration—and this country of ours will be sitting pretty after the war . . . *and so will you.*

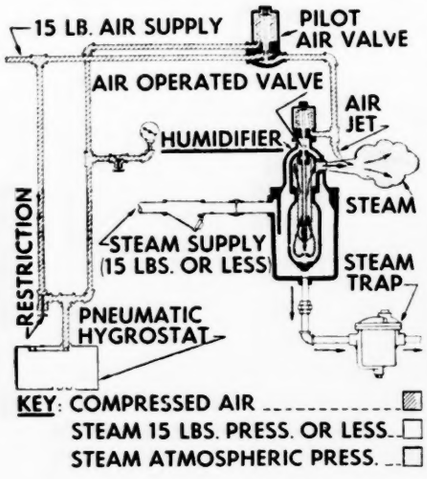
Uncle Sam

KEEP PRICES DOWN!

Use it up • Wear it out
Make it do • Or do without

This advertisement, prepared by the War Advertising Council, is contributed by this magazine in co-operation with the Magazine Publishers of America.

News of Equipment and Materials



Armstrong Safety Humidifier

NAME—Armstrong Machine Works unit humidifier.

PURPOSE — For use in process industries where explosive materials are in process and where a compressed air operated humidifier minimizes the danger of explosion.

FEATURES—Uses compressed air in connection with humidistat to control steam vat on humidifier when required and disseminate exhaust steam into the atmosphere by air blast. With this arrangement there is no spark hazard as with electrically operated units. Cost of humidification is said to be less than 2 cents an hour for 40,000 sq ft of area.

LITERATURE AVAILABLE—Bulletin No. 158.

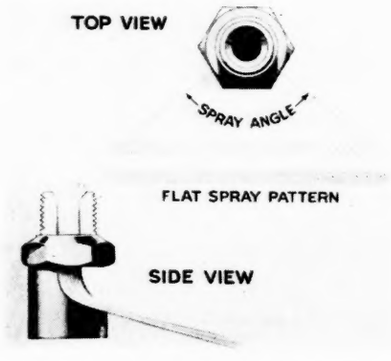
MADE BY — *Armstrong Machine Works, Three Rivers, Michigan.*

Wide Angle Spray Nozzle

NAME — Spraying Systems wide-spray nozzle.

PURPOSE—For use where an exceptionally wide flat spray is required.

FEATURES — Intended for use in spraying eliminator plates and similar applications. Available in brass



and other standard materials. Surfaces making contact with the liquid finely finished.

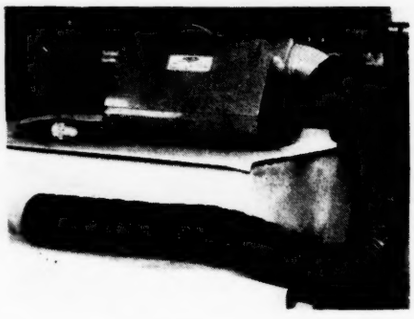
MADE BY—*Spraying Systems Company, Chicago, Ill.*

York Engine Preheater

NAME—York engine preheater.

PURPOSE—To facilitate starting of airplane or other heavy-duty engines during cold weather.

FEATURES—Device weighs 38 lb and can be carried easily by one man. Produces 90,000 Btu per hr and is said to utilize 92% of the heat



in the gasoline it uses for fuel. Suggested applications include snow scrapers, plows, and tractors.

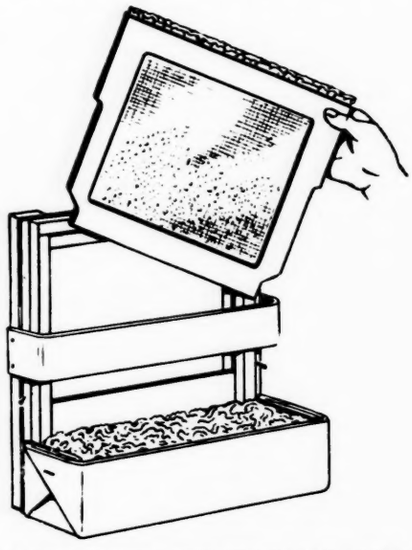
MADE BY—*York Heat, Division of Thos. Shipley, Inc., York, Pa.*

Boxcar Condensation Extractor

NAME—Condensation extractor.

PURPOSE — To extract moisture from air in box cars so as to prevent condensation damage to shipments.

FEATURES—Device is a holder and frame filled with calcium chloride. Holder has a water receptacle at bottom which prevents splashing of accumulated condensation while the cars are being switched. Upper part



of holder is so constructed that nails can be driven to hold unit in position in the car. Holders are nailed inside car just under roof. Number of units needed depends on shipment and climate.

MADE BY — *Albright Condensation Extractor Company, 919 N. Michigan Ave., Chicago, Ill.*

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933, OF HEATING AND VENTILATING, published monthly at New York, N. Y., for October 1, 1943.

State of New York, County of New York, ss.:

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Edgar A. Becker, who, having been duly sworn according to law, deposes and says that he is the Treasurer of The Industrial Press, publishers of HEATING AND VENTILATING, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, The Industrial Press, 140-148 Lafayette St., New York 13, N. Y.

Editor, Clifford Strock, 140-148 Lafayette St., New York 13, N. Y.

Managing Editor, none.

Business Managers, Robert B. Luchars, 140-148 Lafayette St., New York 13, N. Y.; Edgar A. Becker, 140-148 Lafayette St., New York 13, N. Y.; Erik Oberg, 140-148 Lafayette St., New York 13, N. Y.

2. That the owner is:

The Industrial Press, 140-148 Lafayette St., New York 13, N. Y.; Robert B. Luchars, 140-148 Lafayette St., New York 13, N. Y.; Edgar A. Becker, 140-148 Lafayette St., New York 13, N. Y.; Laura A. Brownell, 140-148 Lafayette St., New York 13, N. Y.; Franklin D. Jones, 140-148 Lafayette St., New York 13, N. Y.; Erik Oberg, 140-148 Lafayette St., New York 13, N. Y.; First National Bank and Trust Co. of Montclair and Robert B. Luchars, Trustees (Beneficiaries unknown), Upper Montclair, N. J.; First National Bank and Trust Co. of Montclair and Leigh Roy Urban, Trustees (Beneficiaries unknown), Upper Montclair, N. J.; First National Bank and Trust Co. of Montclair and Kenneth D. Ketchum, Trustees (Beneficiaries unknown), Upper Montclair, N. J. Paterson Savings Institution, Trustee (Beneficiaries unknown), Paterson, N. J.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are:

Laura A. Brownell, 140-148 Lafayette St., New York 13, N. Y.; John Connolly, 140-148 Lafayette St., New York 13, N. Y.; Franklin D. Jones, 140-148 Lafayette St., New York 13, N. Y.; Robert B. Luchars, 140-148 Lafayette St., New York 13, N. Y.; Louis Pelletier, 140-148 Lafayette St., New York 13, N. Y.; Elizabeth Y. Urban, 163 Western Drive, Longmeadow, Mass.; Helen L. Ketchum, King St., Cohasset, Mass.; Wilbert A. Mitchell, 28 Harlow Road, Springfield, Vt.; Henry V. Oberg, 1317 Hill Crest Road, R.D. No. 1, Lancaster, Pa.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

EDGAR A. BECKER, Treasurer.

Sworn to and subscribed before me this 30th day of September, 1943.

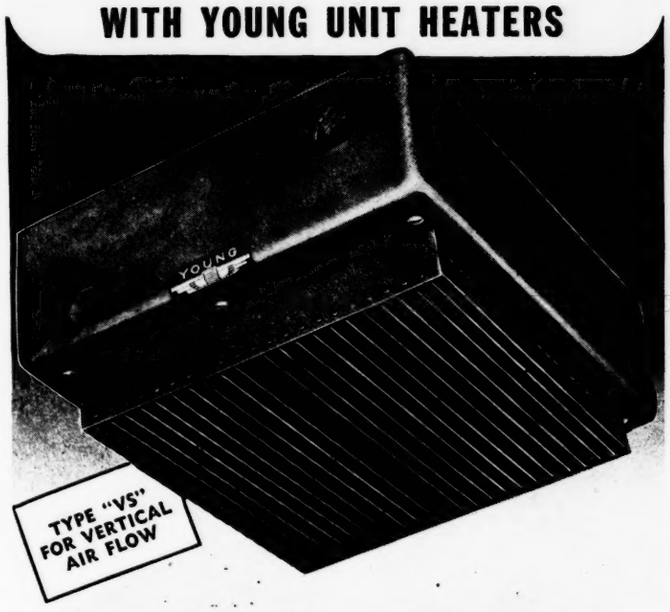
CHARLES P. ABEL.

Notary Public, Kings County No. 292; Kings Register's No. 116-A-5; N. Y. County No. 233; N. Y. Register's No. 153-A-5. My commission expires March 30, 1945.

DISCOMFORT DEFEATS PEAK PRODUCTION

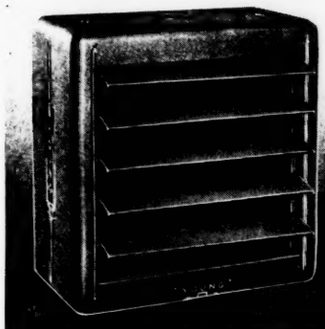
WARM UP *the* COLD SPOTS

WITH YOUNG UNIT HEATERS



More consideration than ever will be given to the comfort and health of war workers this winter . . . not only to prevent illness that results in absenteeism, but to invite employment, build loyalty and morale, and increase production efficiency. If heating facilities were inadequate last year, if cold spots were detected or if departments have been rearranged, Young Streamaire Unit Heaters can be used to advantage. Their saving of floor space, ease of installation, low first cost, efficient operation and low maintenance cost make Young Unit Heaters desirable for existing or new buildings and additions. Write us direct or consult with the Young representative in your locality, for the solution to heating and air conditioning problems.

YOUNG RADIATOR COMPANY
Dept. 143-M Racine, Wis., U.S.A.



TYPE "SHS" FOR HORIZONTAL AIR DELIVERY

BUY BONDS
PRODUCE MORE
SALVAGE SCRAP
WIN THE WAR

YOUNG

HEAT TRANSFER PRODUCTS

Oil Coolers - Gas, Gasoline, Diesel Engine Cooling Radiators - Intercoolers - Heat Exchangers - Engine Jacket Water Coolers - Unit Heaters - Convectors - Condensers - Evaporators - Air Conditioning Units - Heating Coils - Cooling Coils - and a complete line of Heat Transfer Equipment for aircraft.

WARTIME EXPERIENCE

points to

POSTWAR PERFECTION

Since automatic controls are essential to modern, mechanized warfare, the greater part of our production is devoted to turning out vitally necessary precision built equipment.

The specialized skills used to hasten the day of Victory will also serve after the peace is won. When that day comes, knowledge gained from wartime experience will be used to good advantage.

Automatic controls will give the American of tomorrow even higher standards of living and production efficiency than those now enjoyed. We will be ready to maintain our reputation as pioneers and leaders in this field.

Six TIMES MORE POWER

K-10

Write for Catalog 52

Multiply the ordinary solenoid valve by six and you get an idea of the powerful lever action developed by General Controls' K-10. This quiet, two-wire, current failure valve is easy to install on air-conditioning, combustion or refrigeration equipment. K-10 handes air, gas, water, light and heavy oils, and steam. Positive opening and complete shut-off are assured. Designed for either normally closed or open. Available any voltage. A.C. or D.C. and up to 1¼" I.P.S., port sizes up to ⅝".

Degree-Days for October, 1943

HEATING AND VENTILATING'S 16th year of publication of monthly degree-day data

City	Monthly Degree-Days			Cumulative Degree-Days[1]			Year[2]
	Degree-Days, Oct., 1943	Degree-Days, Oct., 1942	Degree-Days, Oct., Normal	Season, 9/1/43-10/31/43	Season, 9/1/42-10/31/42	Season, Normal, 9/1-10/30	Normal, 9/1-6/30
Abilene, Texas	70	106	0	78	125	0	2061
Albany, New York	466	420	446	656	592	518	6580
Albuquerque, New Mexico	250	228	273	264	244	273	4298
Alpena, Michigan	574	525	570	876	798	792	8299*
Anaconda, Montana	557	611	647	781	874	982	8357**
Asheville, North Carolina	316	236	276	430	322	276	4232
Atlanta, Georgia	170	81	96	193	118	96	2890
Atlantic City, New Jersey	269	170	254	338	236	254	5176
Augusta, Georgia	104	41	16	105	59	16	2161
Baker, Oregon	518	491	552	632	678	810	7163
Baltimore, Maryland	273	149	223	327	199	223	4533
Billings, Montana	384	448	524	553	684	713	7119
Binghamton, New York	489	371	453	684	528	561	6808
Birmingham, Alabama	173	70	0	193	105	0	2352
Bismarck, North Dakota	423	555	626	652	906	848	9192
Block Island, Rhode Island	304	278	279	393	369	279	5788
Boise, Idaho	371	401	434	408	507	536	5552
Boston, Massachusetts	355	288	363	475	391	411	6045
Bozeman, Montana	531	586	651	794	883	987	8521**
Buffalo, New York	512	367	419	703	521	494	6822
Burlington, Vermont	529	488	481	759	711	625	7514
Butte, Montana	617	703	655	912	1038	999	8272
Cairo, Illinois	205	143	158	242	217	158	3909
Canton, New York	554	461	557	822	691	746	8020
Charles City, Iowa	501	443	476	747	704	569	7588
Charleston, South Carolina	66	21	0	66	29	0	1769
Charlotte, North Carolina	166	90	115	202	128	115	3120
Chattanooga, Tennessee	215	157	105	239	218	105	3118
Cheyenne, Wyoming	553	583	605	778	874	845	7466
Chicago, Illinois	363	369	350	530	562	350	5957
Cincinnati, Ohio	289	255	254	377	390	254	4684
Cleveland, Ohio	401	296	366	535	431	393	6155
Columbia, Missouri	284	238	260	366	383	260	4922
Columbia, South Carolina	107	38	31	114	59	31	2364
Columbus, Ohio	339	246	313	450	379	313	5398
Concord, New Hampshire	483	467	484	729	657	652	7353
Concordia, Kansas	334	260	276	396	411	276	5315
Dallas, Texas	83	80	0	84	114	0	2256
Davenport, Iowa	343	316	363	479	499	363	6289
Dayton, Ohio	350	272	273	480	408	273	5264
Denver, Colorado	344	423	428	437	576	500	5874
Des Moines, Iowa	374	318	357	534	511	357	6384
Detroit, Michigan	447	365	400	618	553	442	6490
Devils Lake, North Dakota	526	530	706	837	934	982	9970
Dodge City, Kansas	308	268	276	352	367	276	5035
Dubuque, Iowa	409	386	409	600	599	445	6790
Duluth, Minnesota	565	580	626	939	937	896	9443
Eastport, Maine	482	487	543	759	740	819	8520**
Elkins, West Virginia	474	328	378	689	468	441	5697
El Paso, Texas	61	69	40	75	76	40	2428
Ely, Nevada	564	605	—	734	886	—	—
Erie, Pennsylvania	432	315	378	569	435	414	6273
Escanaba, Michigan	549	539	591	892	849	834	8771*
Evansville, Indiana	284	246	155	368	372	155	4244
Fort Smith, Arkansas	150	108	62	150	159	62	3147
Fort Wayne, Indiana	436	373	347	639	557	347	5925
Fort Worth, Texas	73	82	0	76	103	0	2148
Fresno, California	106	74	19	106	74	19	2334
Galveston, Texas	28	0	0	28	7	0	1016
Grand Junction, Colorado	269	308	369	271	347	369	5548
Grand Rapids, Michigan	438	385	419	626	577	476	6535
Green Bay, Wisconsin	502	429	505	774	687	637	7825
Greensboro, North Carolina	257	164	143	325	223	143	3529
Greenville, South Carolina	179	102	146	212	136	146	3380
Harrisburg, Pennsylvania	356	250	329	465	342	329	5375
Hartford, Connecticut	405	334	344	534	444	392	6036
Hatteras, North Carolina	86	27	0	92	29	0	2571
Havre, Montana	469	529	620	700	774	890	8700
Helena, Montana	548	568	614	774	846	865	7898
Houston, Texas	39	10	0	41	25	0	1157
Huron, South Dakota	461	496	526	670	795	649	8004
Indianapolis, Indiana	306	266	298	418	399	298	5298
Kansas City, Missouri	283	218	219	343	354	219	4956
Kewanee, Illinois	384	379	334	554	565	412	6139
Knoxville, Tennessee	260	170	183	304	245	183	3670
La Crosse, Wisconsin	510	431	462	761	669	558	7322
Lander, Wyoming	536	604	654	727	857	930	7947

[1]Cumulative data identical with monthly figures for September only. In subsequent months, cumulative figures will show record for whole heating season to and including month in question.

[2]Figures in this column are normal totals for a complete heating season, September to June, incl.

Figures in this table, with eight exceptions, based on local weather bureau reports. Exceptions are Utica, Lewiston, Kewanee, and Sioux City, figures for which are furnished through the courtesy of Coke Sales Department, Central New York Power Corp., Utica, N. Y.; Norman E. Ross, Bursar, Bates College, Lewiston, Me.; J. M. Hartman, Engineering Department, Kewanee Boiler Corp., Kewanee, Ill., and Alfred R. Wagstaff, Engineer, Sioux City Foundry and Boiler Co., Sioux City, Iowa, respectively; Anaconda, Bozeman, Butte and Livingston, Mont., through the courtesy of the Montana Power Company.

[Table Concluded on page 82]

NON-METALLIC
SAL-MO SUPPLY DUCT

for PUBLIC BUILDINGS – INDUSTRIAL BUILDINGS – HOMES and HOUSING PROJECTS

Sal-Mo Supply Duct is SAFE—Approved and Listed for Safety, Permanence and Heating by *UNDERWRITERS' LABORATORIES, INC.* COMPACT—Exclusive folding feature saves space in cars, storage and in transfer to job; saves time in erection. INSULATING—Built-in insulation assures years of fuel saving. LIGHT—Weighs less than 8 oz. per square foot. STRONG—Withstands Mullens Test of over 400 lbs. per square inch. MOISTURE RESISTANT—Fabricated entirely with insoluble adhesives. High humidity will not separate the various layers.

Manufactured in 26 standard sizes (areas from 26 square inches to 448 square inches, in convenient 4-foot lengths) allowing for all types of installations. It is also furnished in flat sheets containing 11 to 24 square feet which can be easily rolled or scored on the job.

FOR WARM AIR HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

A Typical Duct Installation in a Large Church Building. Sal-Mo Supply Duct Was Used Throughout.

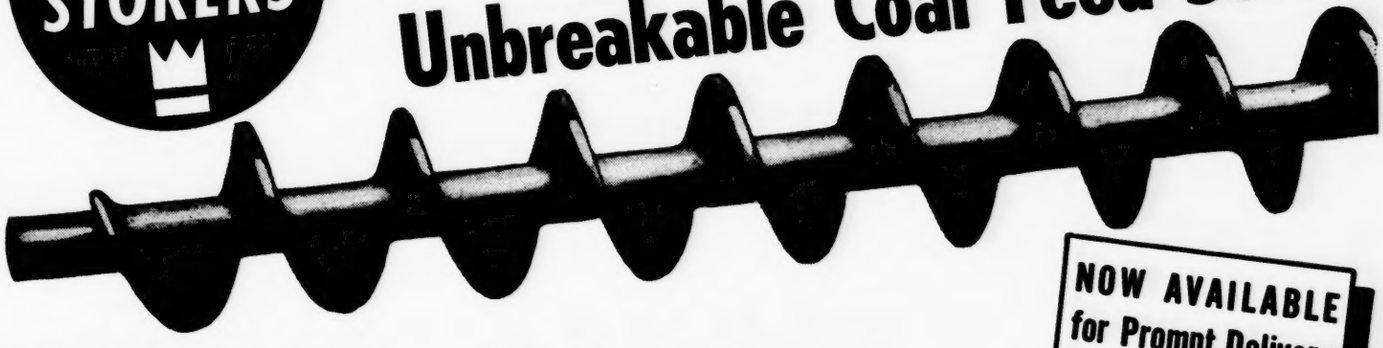
SALL MOUNTAIN COMPANY Asbestos UTILITY SERVICE ECONOMY

SALL MOUNTAIN COMPANY

176 WEST ADAMS STREET • CHICAGO 3 • ILLINOIS

For STOKERS

The CROWN Unbreakable Coal Feed Screw



NOW AVAILABLE for Prompt Delivery

WELDED All-Steel Worm — All Sizes — All Pitches

★ For replacement or production needs, Crown is now able to offer for prompt delivery its unbreakable, all-steel Coal Feed Screw. Available with right or left hand screw, in all sizes and pitches, tapered or straight, and in combinations of pitches. For both domestic and industrial stokers, the Crown Coal Feed Screw insures longer and continuous operation because it is all-steel and because it is machined so smoothly that wear is reduced to a minimum. This smooth surface is your assurance, too, that coal will flow freely and easily through the flights. Prompt delivery is possible because production requires less time on Crown's automatic machines and because the steel used in Crown's Coal Feed Screw, while critical, does not have to contend with the enormous priorities required by the makers of other screws.

In ordering give complete specifications on size and design.

CROWN IRON WORKS COMPANY

1229 Tyler St., N. E. *Since 1878* **Minneapolis, Minn.**

Degree-Days for October, 1943 (Concluded)

HEATING AND VENTILATING'S 16th year of publication of monthly degree-day data

City	Monthly Degree-Days			Cumulative Degree-Days[1]			Year[2]
	Degree-Days, Oct., 1943	Degree-Days, Oct., 1942	Degree-Days, Oct., Normal	Season, 9/1/43-10/31/43	Season, 9/1/42-10/31/42	Season, Normal, 9/1-10/30	Normal, 9/1-6/30
Lansing, Michigan	511	444	481	766	682	595	7048
Lewiston, Maine	510	498	501	510	702	666	7707
Lincoln, Nebraska	364	304	316	448	478	316	5999
Little Rock, Arkansas	140	105	47	143	162	47	2811
Livingston, Montana	435	563	523	648	871	750	7205
Los Angeles, California	49	36	0	49	39	0	1504
Louisville, Kentucky	234	208	186	295	315	186	4180
Lynchburg, Virginia	241	156	220	307	216	220	3980
Macon, Georgia	127	56	6	134	79	6	2201
Madison, Wisconsin	442	414	459	685	645	546	7429
Marquette, Michigan	545	526	567	879	836	792	8693*
Memphis, Tennessee	172	99	62	193	160	62	2950
Meridian, Mississippi	119	66	22	122	102	22	2160
Milwaukee, Wisconsin	456	456	450	691	694	534	7245
Minneapolis, Minnesota	480	457	481	716	739	574	7850
Modena, Utah	437	458	517	501	620	673	6562
Montgomery, Alabama	109	31	0	109	50	0	1884
Nantucket, Massachusetts	302	284	335	405	375	398	5957
Nashville, Tennessee	213	140	136	249	213	136	3507
New Haven, Connecticut	386	285	360	497	376	399	5895
New Orleans, Louisiana	60	17	0	60	22	0	1024
New York, New York	317	202	276	382	255	276	5347
*Nome, Alaska	781	575	1126	781	575	1870	14580**
Norfolk, Virginia	170	65	99	197	89	99	3350
North Head, Washington	328	310	366	536	548	621	5452**
North Platte, Nebraska	410	395	434	520	596	476	6366
Oakland, California	175	146	183	237	251	273	3143**
Oklahoma City, Oklahoma	145	142	105	146	208	105	3613
Omaha, Nebraska	381	310	329	489	494	329	6131
Oswego, New York	499	377	459	693	522	573	7088
Parkersburg, West Virginia	330	216	285	434	340	285	4775
Peoria, Illinois	354	318	381	505	507	384	6109
Philadelphia, Pennsylvania	279	198	242	328	245	242	4855
Phoenix, Arizona	24	18	0	24	18	0	1405
Pittsburgh, Pennsylvania	394	240	313	506	348	313	5235
Pocatello, Idaho	452	459	499	538	620	655	6655
Portland, Maine	492	494	477	732	696	639	7218
Portland, Oregon	279	234	332	309	285	437	4469
Providence, Rhode Island	349	292	348	461	376	411	6015
Pueblo, Colorado	428	391	388	518	513	394	5514
Raleigh, North Carolina	178	108	130	217	148	130	3234
Rapid City, South Dakota	417	482	515	586	766	659	7118
Reading, Pennsylvania	348	244	344	438	327	344	5389
Redding, California	164	83	19	164	83	19	2451
Reno, Nevada	461	417	453	514	559	597	5892
Richmond, Virginia	229	135	161	275	184	161	3695
Rochester, New York	507	390	431	700	548	503	6732
Roseburg, Oregon	285	249	350	312	310	461	4428
Roswell, New Mexico	170	167	186	188	216	186	3484
Sacramento, California	110	71	71	110	73	71	2653
St. Joseph, Missouri	302	247	248	377	405	248	5161
St. Louis, Missouri	219	197	205	275	313	205	4585
Salt Lake City, Utah	334	382	388	360	492	406	5555
San Antonio, Texas	42	16	0	52	29	0	1202
San Diego, California	32	26	34	32	26	34	1645
Sandusky, Ohio	375	308	353	496	441	353	6208
San Francisco, California	131	134	146	232	289	260	3264**
Sault Ste. Marie, Michigan	645	583	623	996	924	899	9285**
Savannah, Georgia	69	16	0	69	22	0	1490
Scranton, Pennsylvania	452	338	397	609	466	457	6129
Seattle, Washington	330	298	394	411	411	580	4934**
Sheridan, Wyoming	479	512	636	717	755	900	8008
Shreveport, Louisiana	90	50	0	91	81	0	1938
Sioux City, Iowa	426	388	415	588	621	448	6898
Spokane, Washington	469	457	515	561	577	707	6355
Springfield, Illinois	276	261	282	358	409	282	5373
Springfield, Missouri	297	233	217	381	363	217	4428
Syracuse, New York	506	399	425	715	566	521	6893
Tacoma, Washington	358	327	400	487	470	607	5181**
Terre Haute, Indiana	272	258	233	377	385	233	4872
Toledo, Ohio	437	348	369	631	512	378	6077
Topeka, Kansas	284	205	236	328	339	236	4969
Trenton, New Jersey	350	242	242	438	308	242	4933
Utica, New York	512	421	430	737	597	612	6796
Valentine, Nebraska	429	479	490	595	743	583	7039
Walla Walla, Washington	351	246	332	364	275	362	4808
Washington, Dist. Columbia	278	153	251	342	212	251	4626
Wichita, Kansas	237	209	192	255	323	192	4673
Williston, North Dakota	480	580	660	742	913	930	9323
Winnemucca, Nevada	437	436	507	465	571	699	6427**
Yakima, Washington	413	339	437	431	371	557	5599

*Includes August. **Includes July and August. (a) Data not yet available.

[1]Cumulative data identical with monthly figures for September only. In subsequent months, cumulative figures will show record for whole heating season to and including month in question.

[2]Figures in this column are normal totals for a complete heating season, September to June, incl.

A Better STRAINER

- Cadmium Plated Inside and Out
- High Grade Woven Monel Wire Screen
- Readily Removed Steel Blow-Off Bushing
- Screen and Bushing Come Out Together—Go Back Together, Automatically Aligning
- For Steam Lines or Water, Oil and Other Fluids
- Reasonably Priced
- 6 Sizes from ½" to 2" for Pressures up to 600 lbs
- Many Thousands in Service
- Sold by Over 100 Mill Supply Houses

See Your Supply House or Send For Bulletin S-200

YARNALL-WARING COMPANY
104 Mermaid Ave., PHILADELPHIA 18, PA.

YARWAY STRAINERS

DE-STA-CO Blower Wheel Housings

of Standard Dimensions

Made in sizes to fit 4½, 5, 6, 7½ and 9 inch wheels and in widths to suit single or double inlet wheels . . . also individual parts for your own assembly.

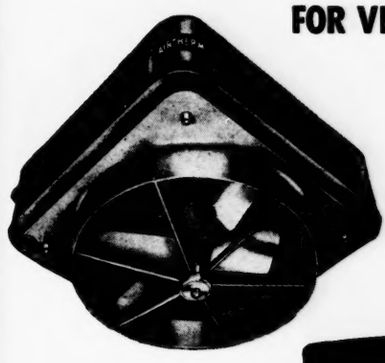
De-Sta-Co housings are engineered for maximum efficiency and quietness in operation . . . neatly finished. Send for "De-Sta-Co Blower Housings" bulletin; gives complete information, including essential dimensions.

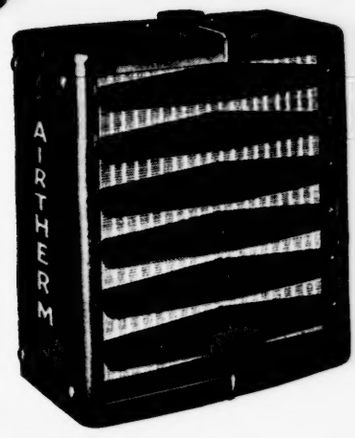
DETROIT STAMPING CO.

Established Over 25 Years

375 Midland Ave • Detroit 3, Mich.

FOR VERTICAL DELIVERY





FOR HORIZONTAL DELIVERY

AIRTHERM UNIT HEATERS

NOW—MORE THAN EVER—
STURDY CONSTRUCTION COUNTS

To insure maximum heat and usage, all Airtherm Unit Heaters have these features:

Extra-heavy tube-wall thickness of .065".

Ingot iron tubes.

Lead-alloy coated condensers for greatest possible protection from corrosion.

Condensers guaranteed to withstand steam pressure up to 150 lbs. per sq. in.

AIRTHERM MANUFACTURING COMPANY

722 S. SPRING AVE., ST. LOUIS, MO.

NEWS OF THE MONTH

ICI Launches Program

DETROIT—A national program of education was launched in behalf of the heating, cooling, and air conditioning industries at the first joint meeting of officers, directors and advisory council to the board of the Indoor Climate Institute held in Chicago early in November.

Pointing out the job that can be done on an industry-wide basis, I.C.I president, Paul B. Zimmerman, said:

"The American public has benefited immeasurably from the cooperative efforts of manufacturers who have been inspired by a desire to have all the members of an industry subscribe to policies, principles and practices which assure the public of better products and better living conditions. The modern kitchen is a perfect example of this educational effort on the part of manufacturers. Better lighting, better wiring—many other of the everyday aids to better living—were stimulated in the same manner.

"Today, heat, next to food, is the most important factor affecting the health of Americans. The activities of the Indoor Climate Institute will include a far-reaching program of training and public education on improved living standards. The home owner will, for the first time, be able to understand and evaluate the many advantages obtainable through modern heating, cooling and air conditioning equipment properly installed. This will assure greater indoor comfort and health." Headquarters of I.C.I. are Detroit, but local authorized chapters will be established in the principal cities of the United States to bring the program into every community.

Fan Group Promoting Anglo-American Collaboration

NEW YORK—During 1940 the Board of Trade in England inaugurated the formation of groups to represent specific industries, included therein is the Fans and Ancillary Equipment Industrial and Export Group. This group is now attempting to establish collaboration and cooperation between air conditioning and heating interests in the two countries with regard to research, development and the manufacture of equipment.

Victor A. Kennett, managing director of Air Conditioning & Engineering, Ltd., 70 Victoria St., London SW1, England, who is now visiting this country, has been asked by the director of the group, Arthur G. Marshall, to get in touch with manufacturers of fans and auxiliary apparatus for the purpose of establishing connections between American firms and the Fans and Ancillary Equipment Industrial and Export Group of England.

It is suggested that interested manufacturers communicate with Arthur G. Marshall in care of the Fans and Ancillary Equipment Industrial and Export Group, 2 Howard St., Strand, London WC2.

The Board of Trade in England corresponds in some respects to the U. S. Department of Commerce.

Speaks on Asphalt Insulation

LOS ANGELES—A wool-like substance derived from asphalt and tentatively named "asphalt wool" was described as one of the recent major laboratory developments in the field of insulation in a talk on industrial asphalts and their relation to the heating and refrigeration industries delivered November 3 by R. H. Hodges of the Pioneer Flintcote Co., Los Angeles, before a meeting of the National Association of Practical Refrigeration Engineers.

The material, Mr. Hodges declared, is still in the experimental stage and not yet ready for commercial manufacture and distribution. It is black in color, of a texture resembling rock wool and light in weight, averaging not more than 9 or 10 pounds per cubic foot compressed. It lends itself well, Mr. Hodges stated, to molding into blocks for boiler wall insulation or to forming into pipe covering, has been found practical as insulation filler in loose wool form, and as caulking for pipe to replace oakum.

$2,500,000 Coal Research Program Planned

COLUMBUS, OHIO—Twelve major research investigations, involving 90 specific problems, have been planned by Bituminous Coal Research as part of a five-year program to cost $2,500,000. Research is being carried on at Battelle Memorial Institute.

One objective is the burning of coal in residences 365 days a year automatically to heat the home in winter and to cool it in summer, with a minimum of smoke.

It was disclosed that smokeless combustion by bituminous coal in home heaters is beyond the experimental stage. Such stoves are to be marketed soon after the war ends.

Attention will be directed to the use of fluid coal, a suspension of finely pulverized coal in air, which can be piped to burners similar to gas or oil. Summer cooling of residences by coal is still in an exploratory state but it is under study, and laboratory experiment will be started when the most promising path becomes apparent.

H. N. Eavenson, president of Bituminous Coal Research, Inc., stated that great benefits from coal involving major improvements are on the way but that some of these will require extensive research before completion. Some of these changes will take place in the immediate post-war period.

A.C. Aids Penicillin Production

LOS ANGELES—Air control and air filtration problems involved in the growing of molds from which the new drug penicillin is produced were described in a talk given at the November meeting of the Southern California Chapter, ASHVE, by Arthur J. Hess, engineer of English & Lauer, Inc. Mr. Hess based his discussion on actual experience he gained in recent laboratory work involving the designing of systems for controlling temperature and humidity in rooms used for penicillin production.

Developing good mold strains and proper feeding of the mold, Mr. Hess asserted, are great aids in stimulating production, but air conditioning has been found to be a major consideration in the growth of the mold and the amount of penicillin obtained from a given amount of mold.

"Molds generally like moist conditions," Mr. Hess stated, "and this mold is no exception. Growing occurs between 70 and 73F dry bulb temperature, and though temperatures can vary from these limits, growth and production stop below and above those figures."

Mr. Hess explained that the need for keeping within such a narrow temperature range requires care and ingenuity in the design of the air distribution system, as well as the design for a proper volume of air. All this, he pointed out, is in addition to the design for the cooling and heating system. The maintenance of temperature within the narrow tolerances mentioned, he stated, poses one of the major problems in the design

(Concluded on page 86)

WING AXIAL FLOW BLOWERS

Type EMD (Single Stage)

Used for statics up to 5" with volumes up to 35,000 cfm. Higher capacities can be furnished in special designs. Built-in volume control and re-directing vanes permit simplified capacity variation either manually or automatically. Falling horsepower characteristics with dampering. Motors are constant speed, fully enclosed and dustproof. Static efficiencies up to 70% and more. Uses: Forced draft for oil or gas burners, stokers, pulverized fuel, and hand-fired boilers. Mounted horizontally or vertically; on floor, or directly on windboxes or air preheaters.

L. J. Wing Mfg. Co.

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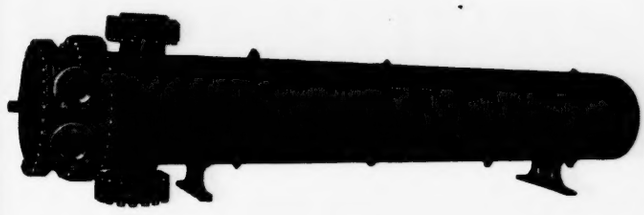
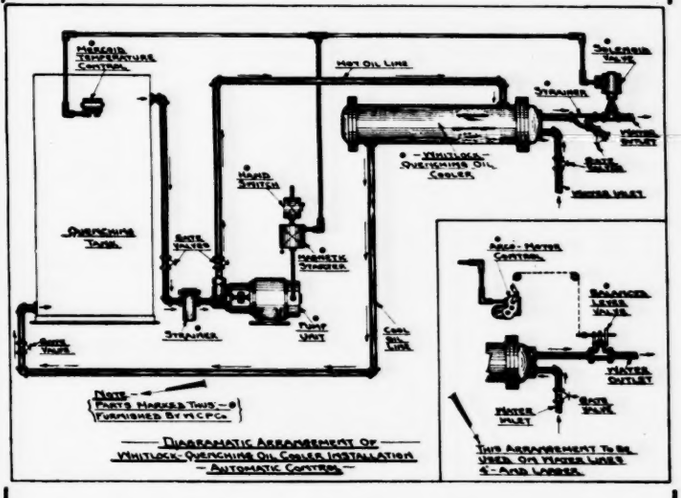
WHITLOCK

QUENCHING OIL COOLERS



The modern method of keeping quenching oil uniformly at the correct temperature in the heat treatment of steel—and the most successful, practically and economically—is to circulate quenching oil from the top of the tank through a WHITLOCK Quenching Oil Cooler and back to the tank again. Because of its efficiency, this method consumes a minimum of water and is, therefore, particularly economical for use in plants dependent upon municipal water supplies.


Hot Oil Line
Strainer
Quenching Tank
Cold Oil Line
Note — Parts Marked Thus — ● Furnished By W.C.P.Co.
Diagrammatic Arrangement Of Whitlock Quenching Oil Cooler Installation — Automatic Control
This Arrangement To Be Used On Higher Lines $ - And Larger.

WHITLOCK Quenching Oil Cooler can be located out of the way with circulating pipes running to the various quenching tanks as shown above.

Write for our chart K-300, for determining the optimum size of Quenching Oil Cooler for any given conditions.

The WHITLOCK MANUFACTURING CO.

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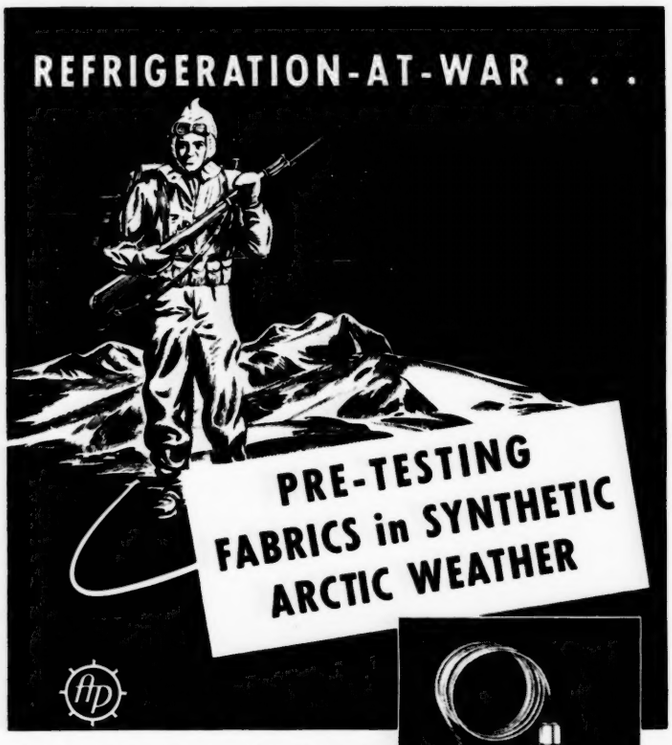
District Offices in New York, Boston, Chicago, Philadelphia, Detroit, Richmond.

Whitlock Equipment (Whitlock-Darling) is manufactured in Canada by Darling Brothers, Ltd., Montreal



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Thermostatic Expansion—Solenoid—Constant Suction Pressure — Water Regulating—"Trap-Dri" System Protectors — Water Solenoids — Cooling Thermostats.

Model 205 Thermostatic Expansion Valve

• "Synthetic Arctic Weather," refrigerated test chambers for pre-testing combat clothing, fabrics, guns and equipment, is but one of many precision-control applications of A-P Dependable Refrigerant Valves . . . saving time, money, and lives today.

A-P DEPENDABLE Refrigerant Valves are a highly vital part of many of today's refrigeration and air conditioning systems. Their long-established reputation for accurate and dependable refrigerant control, and for smooth, "service-free" operation, is an efficiency that you will want to add to YOUR systems — both on new installations and for replacement purposes. A-P valves are available in all capacities, for Freon, methyl chloride, and sulphur dioxide.

Remember, too, when you want effective system protection, the A-P "Trap-It" and "Trap-Dri." Placed ahead of every expansion valve, they effectively trap all system impurities and moisture — permitting smoother valve operation and preventing freeze-ups. . . . *Write for details.*

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Export Dept. . . . 15 East 40th Street, New York 16, New York
Stocked and sold by progressive refrigeration jobbers everywhere, used and recommended by leading service engineers.

News of the Month

(Concluded from page 84)

of an air control system for a penicillin room. Another difficulty, he said, is the need for also maintaining wet bulb temperatures between the same limits of 70 to 73F.

Mr. Hess touched next on the necessity of air filtration in the penicillin production room. Mold spores, he pointed out, float around in the air. The mold is a very low form of plant growth and usually exists in a fuzzy state so that it can easily be carried through the air.

The problem brought on by floating mold in penicillin rooms, Mr. Hess declared, is comparable to the condition which formerly confronted brewery operators involving wild yeast-mold spores which upset beer formulas regardless of how carefully the flow of raw materials to the beer producing equipment was controlled. In penicillin production, he stated, wild spores could upset the whole mold strain unless control methods in the form of careful filtration of the air are used.

Predicts Coal will Regain Heating Market

BIRMINGHAM—A prediction that coal will regain markets lost to gas and oil was made by Ralph A. Sherman, supervisor of the fuels division of Battelle Memorial Institute, Columbus, Ohio, and former fuel engineer for the U. S. Bureau of Mines, in addressing a meeting of the Southeast section, American Institute of Mining and Metallurgical Engineers in Birmingham November 5. His subject was "Fuels of the Future."

Mr. Sherman explained that there was a growing need for the conservation of gas and oil resources, that coal constituted 89.9% of our fuel resources and that great progress was being made in the improvement of coal burning equipment. He pointed out that both anthracite and bituminous coal bodies now have research programs under way designed to improve the utilization of these respective fuels.

Important experiments in the smokeless combustion of coal are being made at the University of Illinois and at Battelle Memorial Institute, Mr. Sherman continued, and manufacturers are only awaiting the release of materials to come out with improved fire apparatus. He predicted there would be stokers of radical design after the war, and that there would be much improvement also in hand-fired stoves, furnaces and boilers.

York Builds —70F Firing Range for Testing Guns

NEW YORK—New heavy caliber aircraft cannon soon will pump their shells over an amazingly short firing range—a distance of 22 feet—as engineers at the Eglin Field, Fla., Army Air Forces proving ground test the effectiveness of the big guns in a man-made stratosphere atmosphere at —70F.

The firing range, designed by York Corporation refrigeration engineers, will be twin steel vacuum chambers where temperature and air pressure will duplicate the stratosphere nine miles above the earth. In this atmosphere, shells will leave the muzzle of the guns, travel the length of the 22-foot range and plow into 20 tons of sand, according to John Bergdoll, chief of the York laboratories.

J. F. Nickerson

CHICAGO—J. F. Nickerson, publisher of "Ice and Refrigeration," "Merchandising Ice," and "Refrigerating Service Engineer," died here October 20 after a six months illness. He was 82.

Long active in the refrigeration industry, Mr. Nickerson was especially so in association affairs. He fostered the Refrigeration Service Engineers Society and was one of the pioneers in the formation of the American Institute of Refrigeration and other societies.

PORCELAIN AND ENAMELED IRON

The American Rolling Mill Co., Middletown, Ohio.

A data book for production engineers, designers, architects, and engineers and containing information on the abrasion and friction resistance, weather resistance, resistance to chipping, resistance to thermal shock, color fastness and range, finishes available, chemical resistance and physical properties of porcelain enamel. Standard size, 24-pages.

GASKETS

Goetze Gasket & Packing Company, Inc., New Brunswick, N. J.

A gasket chart showing cross-sections of 36 popular gasket purposes and their characteristics. Copies should be requested on business letterheads.

CALCULATION OF PIPE WALL THICKNESS

Midwest Piping & Supply Co., Inc., St. Louis 4, Mo.

A 16-page bulletin intended to simplify and collect under one cover essential data needed for the easy and rapid determination of pipe wall thicknesses at various temperatures, based on the schedule number method. Comparison charts show the commercial wall thicknesses of pipe from ½ in. to 24 in. inclusive and are in accordance with the standards of the A.S.A.

CONDENSER TUBES

Bridgeport Brass Co., Bridgeport 2, Conn.

A 112-page, 6 x 9 in., booklet entitled Condenser Tube Manual. It fulfills the need for a compact ready-reference on tubes used in condensers, heat exchangers and evaporators, and deals with comparatively new and more corrosion-resisting alloys, such as Duronze IV, Cupro Nickel, Cuzinal, as well as improved Admiralty, Muntz and Copper. Much space is devoted to corrosion research covering effects of electro-chemical theory of corrosion, types of protective films, oxygen and debris, impingement corrosion, operating conditions, etc. Also discussed are galvanic corrosion and protection, influences of temperature, water composition, minerals, carbon dioxide and sulphur. Stress corrosion and corrosion fatigue are also covered. Includes the latest A.S.T.M. and Federal specifications on standard alloys, comprehensive weight tables, steam notes, methods of installing and packing, cutting and removing condenser tubes, weight tables and data on brass and copper pipe, copper water tubing and navy type copper tubing.

BOILER WALLS

Geo. P. Reintjes Company, 2517-19 Jefferson St., Kansas City, Mo.

A 4-page folder devoted to the company's sectionally-supported upper side walls for bent-tube boilers which, it is claimed, contribute substantially to fuel conservation.

AIR EXHAUSTER SYSTEMS

G. C. Breidert Co., 634 S. Spring St., Los Angeles 14, Calif.

Two illustrated folders showing the operation of the Air-X-Hauster for use in removing air from industrial and residential buildings. Photographs of models and applications are shown, and tables are given on the overall dimensions and weights of the units.

VACUUM CLEANING SYSTEMS

Allen Billmyre Company, 431 Fayette Ave., Mamaroneck, N. Y.

A central vacuum cleaning system is illustrated and described in an 8-page bulletin. The system consists of a centrifugal exhauster and a separating system provided with a secondary separator and filter tank for removing fine dust particles from the air stream.

★Dealers! Develop A

PERMANENT PROFITABLE STOKER BUSINESS...

★Help Building Owners

SAVE FUEL

with

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FIRST CHOICE OF AMERICA'S FOREMOST HEATING ENGINEERS

Stoker dealers have a unique opportunity to aid the war effort and—at the same time—earn worthwhile profits for themselves by converting hand-fired plants to stoker-firing! *Do your part by speeding these conversions with Freeman Long-Life Stokers.* They have proved their superior efficiency and economy in thousands of installations throughout the world . . . are manufactured by a pioneer leader in the stoker industry, rated AAA 1, established 1864. No other wartime service enables you to cooperate so effectively with the government's fuel conservation program; no other company offers you such an outstanding opportunity to develop a permanent, profitable stoker business. Write today for complete details on our aggressive promotion program that means essential help for Uncle Sam . . . sales-winning success for you!

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Why wait?

The Herman Nelson Corporation, manufacturers of Heating and Ventilating products, whose advertisement appears on pages 4 and 5 of this issue, has positions available in several cities for sales engineers. Don't wait until after the war to establish yourself with a leading, responsible manufacturer in this industry. If you believe that you could fill one of these positions, send complete information about yourself to

ARMY E NAVY

THE HERMAN NELSON CORPORATION

Manufacturers of Quality Heating, Ventilating and Air Conditioning Products

MOLINE, ILLINOIS

PERSONALS AND PERSONNEL

J. MURRAY WHITWORTH

has been appointed to the Pittsburgh area as a sales representative of Jenkins Bros. He succeeds John J. Simpson who resigned to become general sales manager of Pittsburgh Gage & Supply Company. Mr. Whitworth has been connected with the company's Philadelphia branch for the past seven years as representative in Baltimore and Harrisburg.

J. C. LEWIS

has been appointed field representative by Drayer & Hanson, Inc., Los Angeles, Calif., to cover Arkansas, Louisiana, Texas and Oklahoma. He will headquarter in Austin, Texas.

BEN R. SHAVER

treasurer of the American Air Filter Co., Inc., Louisville, has been elected to membership in the Controllers Institute of America, a technical and professional organization of controllers devoted to improvement of controllership procedure.

CHICAGO NIPPLE MFG. CO.

has appointed Robert H. Brink as purchasing agent, and D. Mackintosh as general superintendent and works manager. Mr. Mackintosh spent several years doing consulting engineering work, specializing in machine production and factory managerial systems.

P. W. STICKNEY

has been appointed sales representative for The Allen Corporation, according to B. K. Paget, sales manager. Mr. Stickney, whose office is located at 549 West Washington Blvd., Chicago, will cover the Chicago territory. Associated with him are a designing engineer, R. G. Rosenbach, and two sales engineers, B. B. Harter and M. A. Norman.

Lawrence H. Gardner has been appointed to the Allen engineering staff. Mr. Gardner has been engaged in engineering design work for various industrial equipment manufacturers since 1929. In his new connection, he will devote his attention to design improvements in the company's line of ventilating equipment as well as aid in the development of products planned for post-war markets.

WITH THE MANUFACTURERS

LELAND ELECTRIC COMPANY

Dayton, Ohio, has appointed Paul D. Dale sales manager. Mr. Dale was formerly district manager of the Chicago territory. He takes the place of W. F. Lisman, who has been appointed vice-president and general manager. F. E. Schumacher succeeds Mr. Dale as district manager of the Chicago territory.

H. A. THRUSH & CO.

Peru, Indiana, has appointed George H. Fox as manager of its Philadelphia territory, including Eastern Pennsylvania, South Jersey and Wilmington, Delaware. C. Lawrence Sargent, who has been temporarily covering that territory, has returned to the factory to take up his former duties as head of the engineering department.

STAYNEW FILTER CORP.

Rochester, N. Y., will henceforth be known as Dollinger Corporation, taking this name from Lewis L. Dollinger, president and founder of the company. Recently expanded manufacturing facilities have made possible the development of new products which are soon to be announced. Since certain of these are products other than filters, it seemed advisable to change the company name to one of a more general character. The Staynew and Protectomotor trade-marks will continue to be used in connection with all filter products. There is no change whatever in the management, financial organization, or general policies of the company.

INDUSTRIAL DEGREE DAYS
September and October, 1943

City	Number of Industrial Degree Days			
	55F Base		45F Base	
	September	October	September	October
Baltimore	0	57	0	0
Buffalo	40	233	0	39
Chicago	20	143	0	19
Cleveland	16	153	0	15
Detroit	32	203	0	0
Indianapolis	7	107	0	14
New York	1	86	0	0
Philadelphia	0	61	0	0
Pittsburgh	10	146	0	13
St. Louis	0	79	0	8

ARMY — NAVY E AWARDS

York Corporation, York, Pa.

A. M. Byers Company, Pittsburgh, Pa. (Renewal star).

Buensod-Stacey, Inc., New York, N. Y.

Peerless of America, Inc., Marion, Ind.

Ladish Drop Forge Company, Cudahy, Wis. (Addition of star).

COMING EVENTS

DEC. 8-9 — 30th Annual Convention of the National Warm Air Heating and Air Conditioning Association to be held at the Netherlands Plaza Hotel, Cincinnati, Ohio.

JAN. 31—FEB. 2—50th Annual Meeting of the American Society of Heating and Ventilating Engineers to be held at the Hotel Pennsylvania, New York, N. Y.

BARBER-COLMAN

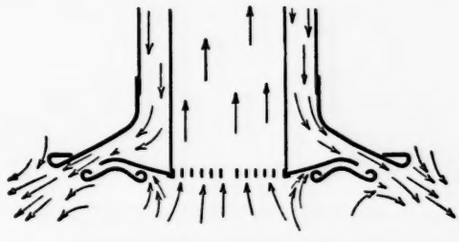
GRILLES & REGISTERS — AIR DIFFUSERS — ENGINEERED Venturi-flo OVERHEAD AIR DIFFUSERS — AIR DISTRIBUTION — AUTOMATIC CONTROLS

COMBINATION

SUPPLY and EXHAUST

Venturi-flo

AIR DIFFUSERS



CROSS-SECTION. This drawing, with arrows indicating the air paths, shows the construction of this type of VENTURI-FLO Air Diffuser. The exhaust duct is connected to the center section having a concentric ring grille. The supply duct surrounds the exhaust duct and is connected to a collar on the largest plate.

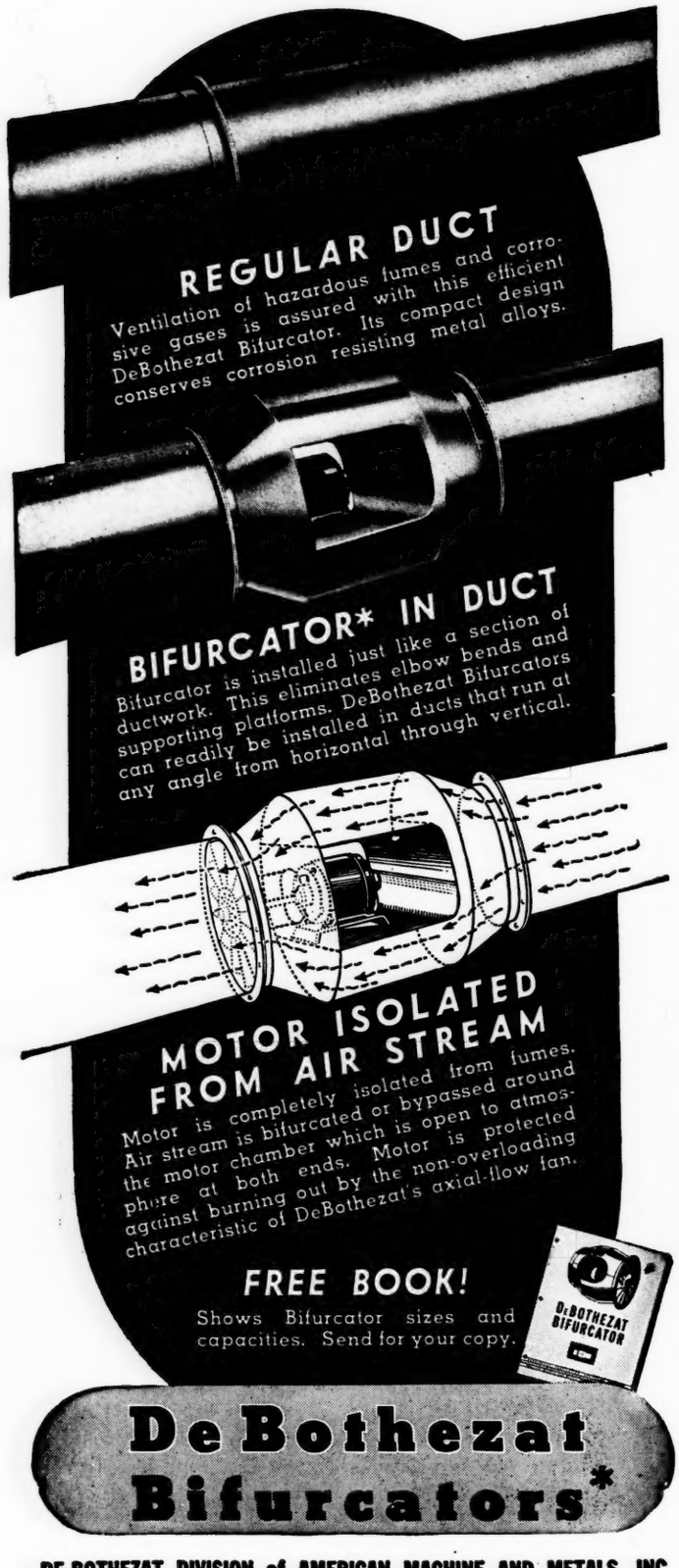
★ **CANNOT SHORT-CIRCUIT.** As shown in the drawing, the incoming and outgoing air streams are so nearly at right angles that supply air is not sucked into the exhaust duct.

★ **LOW PRESSURE DROP.** Contours of the distribution plates were experimentally determined to provide minimum resistance to air flow, quiet air delivery, and a "venturi" action to produce desired diffusion.

★ **GUARANTEED AIR DISTRIBUTION.** From comprehensive laboratory and service test data, exactly the proper unit for any conditions can be selected, and *satisfactory results guaranteed.*

BARBER-COLMAN COMPANY 1224 ROCK STREET ROCKFORD, ILLINOIS

This
DIFFERENT TYPE VENTILATING UNIT*
installs in the Duct


REGULAR DUCT
Ventilation of hazardous fumes and corrosive gases is assured with this efficient DeBothezat Bifurcator. Its compact design conserves corrosion resisting metal alloys.
BIFURCATOR* IN DUCT
Bifurcator is installed just like a section of ductwork. This eliminates elbow bends and supporting platforms. DeBothezat Bifurcators can readily be installed in ducts that run at any angle from horizontal through vertical.
MOTOR ISOLATED FROM AIR STREAM
Motor is completely isolated from fumes. Air stream is bifurcated or bypassed around the motor chamber which is open to atmosphere at both ends. Motor is protected against burning out by the non-overloading characteristic of DeBothezat's axial-flow fan.
FREE BOOK!
Shows Bifurcator sizes and capacities. Send for your copy.
DeBOTHEZAT BIFURCATOR

De Bothezat Bifurcators*

DE BOTHEZAT DIVISION of AMERICAN MACHINE AND METALS, INC.
EAST MOLINE, ILLINOIS

Dust Problem Solved

(Concluded from page 66)

England farm in March represented a value in excess of $350,000. While the skin of a single animal will bring only about $250, the $1200-$1600 valuation per pair is based on their potential breeding value.

This valuation is brought within comprehensible realms when a few figures on chinchilla coat production are weighed: It takes the skins of 80 to 85 animals to make a chinchilla coat 42 to 44 inches long; cost of the skins is approximately $250 each; cost of skins alone for one coat is $18,000 to $20,000. To this amount must be added the tailoring cost and retailer's sales profit before the coat is ready to drape the shoulders of the fortunate lady who will become the eventual possessor.

Fatality Insurance

As insurance against fatalities at birth, the owners of chinchillas boarded at the England farm operate on a breeding grouping arrangement. A group of animal owners signs a grouping agreement. The agreement provides that in the event the female (considered the more valuable of the pair) should die, she will be replaced at no cost to the owner with another female born to the pool as soon as the *get* of the pool doubles. If 12 owners, for instance, each contributes one pair to the grouping arrangement, the owner whose female has died during the tenure of the agreement receives a replacement as soon as the number of female animals in the pool has doubled.

When births of females have increased the female count of the 12-owner pool to 24, and after required replacements for fatalities have been made, the original pair is returned to each owner. Thereafter the remaining animals which have been born to the pool are distributed among the agreement participants by drawing lots.

Tattoo Mark in Ear

The average life of a chinchilla in captivity now is about eight years Each animal at the England farm has an identifying serial number tattooed in indelible ink on the inside of an ear. The serial number is filed with the National Chinchilla Breeders' Association shortly after the birth of an animal. This system, England reported, has reduced theft of live chinchillas from breeding farms to a negligible degree. The reason is that the thief could not sell a registered animal, and the tattooed serial number can not be removed from the animal's ear without mutilating the animal and affecting the value of the skin.

Treidler & Gratiot, air conditioning consultants and engineers of Los Angeles, made the installations; Super-Cold Corporation, Los Angeles, supplied the refrigeration compressor; Air-Maze filters were used.

LINEAR EXPANSION OF PIPE

(In Inches per 100 Ft.)

Temp., F	Material			Temp., F	Material		
	Steel	Wrought Iron	Copper		Steel	Wrought Iron	Copper
0	0	0	0	390	3.156	3.291	4.532
10	0.075	0.078	0.111	400	3.245	3.383	4.653
20	0.149	0.156	0.222	410	3.334	3.476	4.777
30	0.224	0.235	0.333	420	3.423	3.569	4.899
40	0.299	0.313	0.444	430	3.513	3.662	5.023
50	0.374	0.391	0.556	440	3.603	3.756	5.145
60	0.449	0.470	0.668	450	3.695	3.850	5.269
70	0.525	0.549	0.780	460	3.785	3.945	5.394
80	0.601	0.629	0.893	470	3.874	4.040	5.519
90	0.678	0.709	1.006	480	3.962	4.135	5.643
100	0.755	0.791	1.119	490	4.055	4.231	5.767
110	0.831	0.871	1.233	500	4.148	4.327	5.892
120	0.909	0.952	1.346	520	4.334	4.520	6.144
130	0.987	1.003	1.460	540	4.524	4.715	6.396
140	1.066	1.115	1.575	560	4.714	4.911	6.650
150	1.145	1.198	1.690	580	4.903	5.109	6.905
160	1.224	1.281	1.805	600	5.096	5.309	7.160
170	1.304	1.364	1.919	620	5.291	5.510	7.417
180	1.384	1.447	2.035	640	5.486	5.713	7.677
190	1.464	1.532	2.152	660	5.583	5.917	7.938
200	1.545	1.616	2.268	680	5.882	6.122	8.197
210	1.626	1.701	2.384	700	6.083	6.351	8.460
220	1.708	1.786	2.501	720	6.284	6.539	8.722
230	1.791	1.871	2.618	740	6.488	6.749	8.988
240	1.872	1.957	2.736	760	6.692	6.961	9.252
250	1.955	2.044	2.854	780	6.899	7.175	9.519
260	2.038	2.130	2.971	800	7.102	7.384	9.783
270	2.132	2.218	3.089	820	7.318	7.607	10.056
280	2.207	2.305	3.208	840	7.529	7.825	10.327
290	2.291	2.393	3.327	860	7.741	8.045	10.598
300	2.376	2.481	3.446	880	7.956	8.266	10.872
310	2.460	2.570	3.565	900	8.172	8.489	11.144
320	2.547	2.659	3.685	920	8.389	8.713	11.420
330	2.632	2.748	3.805	940	8.608	8.939	11.696
340	2.718	2.838	3.926	960	8.830	9.167	11.973
350	2.805	2.927	4.050	980	9.052	9.396	12.253
360	2.892	3.017	4.167	1000	9.275	9.627	12.532
370	2.980	3.108	4.289	1100	10.042	10.804	13.950
380	3.069	3.199	4.411	1200	11.598	12.020	15.397

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H. & V.'s REFERENCE DATA – 237

LINEAR EXPANSION OF PIPE

Expansion of pipe in ordinary temperatures (in fact up to at least 1500F) can be calculated according to the formula:

$$L_t = L_o \left[1 + a \left(\frac{t-32}{1000} \right) + b \left(\frac{t-32}{1000} \right)^2 \right]$$

where L_t = the length in feet at tF

L_o = the length in feet at 32F

t = the final temperature, F

a and b = constants as follows: steel, a, 0.006212, b, 0.001623; wrought iron, a, 0.006503, b, 0.001622; copper, a, 0.009278, b, 0.001244; cast iron, a, 0.005441, b, 0.001747.

When this formula is solved the difference between L_t and L_o is the expansion, *in feet.*

Using zero as a base the table on the other side of this sheet has been computed from this formula in order to simplify its solution. It is used as follows:

Example: A 740-foot steel pipe line was installed during 60F weather. What is the computed expansion of the line when 420F steam is turned on in the line?

SOLUTION: Under "Steel," opposite 420F, find 3.423; opposite 60F find 0.449. Subtracting gives 2.974 in. expansion per 100 feet. For 740 feet the expansion is $7.4 \times 2.974 = 22.076$ in.

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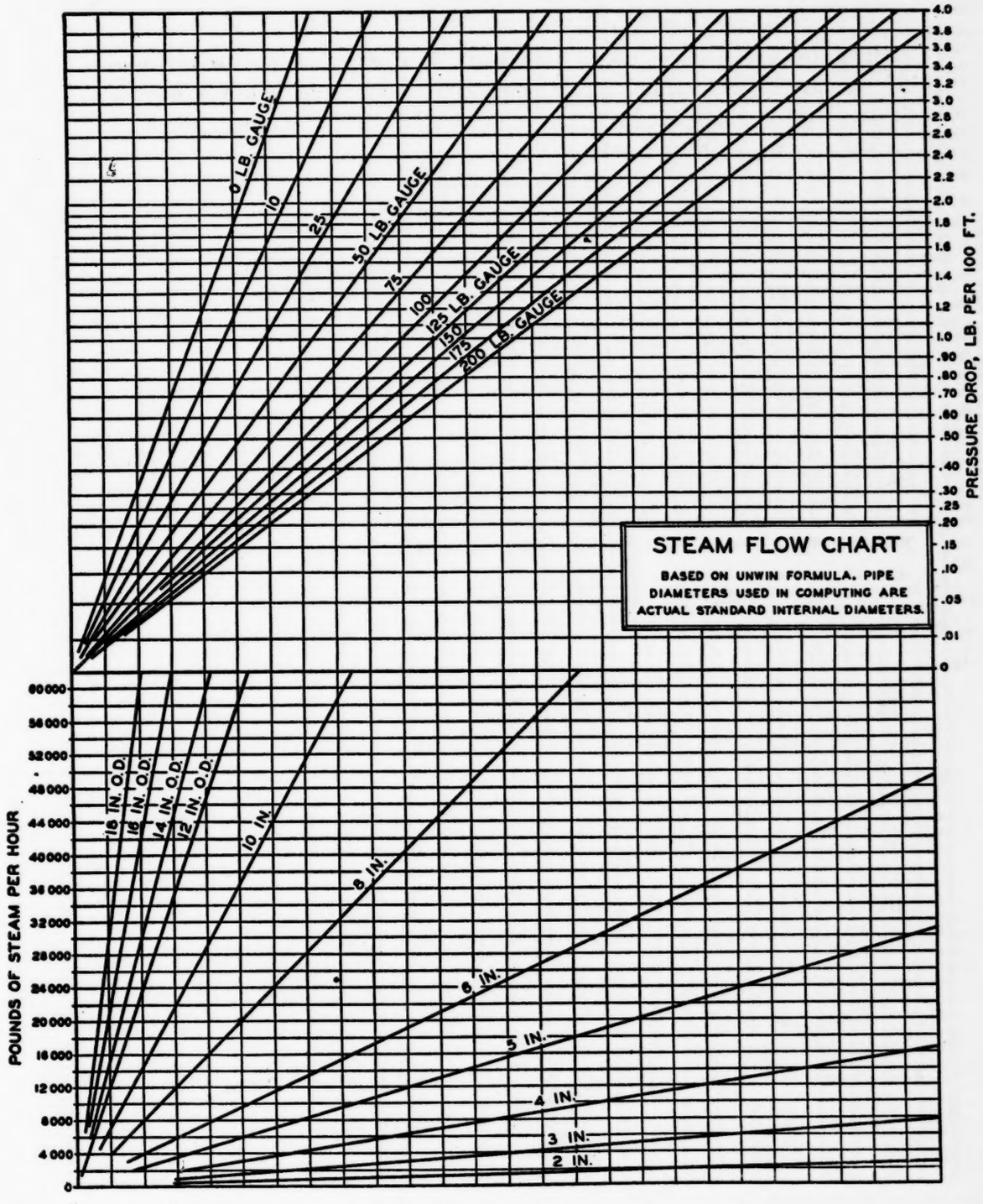
STEAM PIPE SIZING CHART



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H. & V.'s REFERENCE DATA—239

STEAM PIPE SIZING CHART

It is frequently convenient to have available a graphical solution of Unwin's formula for steam pressure drop in piping, since his formula is widely used and, in fact, over ordinary ranges gives almost identical results as one or two others. Unwin's formula can be expressed as

$$p = \frac{2.108VLW^{1.852}}{10^7 \times D^{4.973}}$$

Where p = pressure drop, lb per sq in,
V = specific volume of steam, cu ft per lb,
L = equivalent length of pipe, feet,
W = quantity of steam flowing, lb per hr, and
D = inside diameter of pipe, inches.

The chart on the reverse side of this sheet is a graphical solution of this formula *for a 100 foot length.* It is intended for use in central heating and similar projects involving relatively large piping; it is *not* intended for sizing the smaller low pressure steam mains, branches or risers within a building.

In the chart standard inside pipe diameters have been used, so that in solving a problem involving 6 in. pipe, for instance, the user is safe in using the 6 in. line on the chart.

In using this formula for pipe sizing it is advisable to compute each hundred foot section separately. That is, at the end of the first hundred feet subtract the pressure drop from the initial gauge pressure and re-enter the chart for the second hundred feet, and so on until the end of the line.

The following example shows how the chart is used:

Example: What will be the pressure drop in a 100 foot long 6 in. pipe line carrying 32,000 lb per hour of steam at 100 lb per sq in. gauge pressure?

SOLUTION: Enter at 32,000 on the vertical scale, lower left, and move horizontally to the diagonal line labeled 6 in. From the intersection of the line and the diagonal move vertically to the diagonal line labeled 100. From the intersection move horizontally to the upper right scale and read 2.8 lb per 100 feet.

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ESTIMATING WATER VAPOR TRANSMISSION THROUGH WALLS

This sheet is a companion to H&V's Reference Data 243-244 and is to be used in conjunction with it in calculating the amount of moisture flowing through walls due to a difference in vapor pressure. Table 1, which begins on this sheet is concluded on sheet 243-244 which also contains data on vapor flow through slits (Table 2), a vapor pressure table (Table 3), explanation of the use of the tables, together with the solution of a problem.

TABLE 1—WATER VAPOR TRANSMITTED THROUGH VARIOUS BUILDING MATERIALS†

Material*	Thickness, Inches	Permeability: Grains per Sq Ft per Hr per Lb per Sq In. Vapor Pressure Difference	Vapor Resistance (Reciprocal of Permeability)
Air			
Still Air	1.0	257.0	0.004
Still Air	3.625	70.9	0.014
Building Felts			
Asphalt Saturated Asbestos			
15 lb*	0.028	26.6	0.038
20 lb, one surface asphalt coated	0.032-0.034	0.28 - 0.34	2.92 - 3.56
50 lb, saturated—not coated	0.051	0.77	1.43
Asphalt Saturated Rag			
10 lb	0.025	2.0 - 12.9	0.078- 0.5
15 lb	0.033-0.038	2.16 - 6.16	0.16 - 0.46
20 lb	0.035-0.039	0.925- 1.02	0.98 - 1.08
25 lb	0.050-0.061	51.8 - 62.8	0.016- 0.019
30 lb	0.060-0.068	1.05- 12.8	0.078- 0.95
Johns-Manville, 30 lb			
One sheet	0.062	3.65	0.274
Two sheets	—	2.36	0.423
Three sheets	—	1.87	0.535
Asphalt Saturated and Coated			
Regal coated, one surface, 20 lb	0.038	0.43	2.32
Super-regal, coated one surface, 25 lb	0.031	0.58	1.72
Supertite sheathing, coated both surfaces			
Light	0.036	0.28	3.58
Heavy	0.045	0.185	5.4
Light, coated both surfaces, 15 lb	0.036	0.34	2.94
Super, coated both surfaces, 18 lb	0.045	0.123	8.14
Base felt, coated both surfaces, 42 lb	0.074	0.154	6.5
Coated one surface	0.036	0.308	3.25
Carpet Felt			
17 oz	0.056	339.0	0.003
Tar Saturated Asbestos			
15 lb	0.029	3.42	0.292
Tar Saturated Rag			
12.5 lb (7 oz)	0.028-0.032	1.36 - 57.0	0.018- 0.735
15 lb (10 oz)	0.030-0.042	11.6 - 78.5	0.013- 0.086
25 lb (16 oz)	0.047-0.060	2.44 - 69.0	0.015- 0.42
Concrete			
Concrete			
Plain	1.5	3.57	0.28
With two coats asphalt	1.5	3.18	0.314
Plaster			
Plaster			
½ in. on metal lath	—	32.5	0.031
¾ in. on metal lath	—	27.4	0.036
1 in. on metal lath	—	22.5	0.044
½ in. on wood lath	—	13.7	0.073
½ in. on ⅜ in. gypsum board	—	22.9	0.044
½ in. on ½ in. wood fiber board	—	33.3	0.030
Solid plaster	1.34	27.1	0.037
Wood			
Cedar			
Siding	—	3.69	0.271
Siding with three coats white lead paint	—	2.06	0.485
Pine			
Unpainted	0.80	1.88	0.53
Unpainted	0.645	2.52	0.40
Unpainted	0.496	3.45	0.29
Unpainted	0.315	5.64	0.177
Unpainted	0.169	9.64	0.104
Spruce			
Unpainted	0.563	3.48	0.288
Unpainted	0.480	4.04	0.248
Unpainted	0.405	3.94	0.254
Unpainted	0.323	4.93	0.202
Unpainted	0.232	7.24	0.138
Unpainted	0.161	10.7	0.093

*Note: All weights in Col. 1 are in pounds per 100 sq. ft.

(Continued on other side)

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TABLE 1. (Concluded)—WATER VAPOR TRANSMITTED THROUGH VARIOUS BUILDING MATERIALS†

Material*	Thickness, Inches	Permeability: Grains per Sq Ft per Hr per Lb per Sq In Vapor Pressure Difference	Vapor Resistance (Reciprocal of Permeability)
Paint Films Only			
Aluminum Bronze (Bronzing liquid vehicle)			
On plaster, two coats	—	7.17	0.139
On plaster, three coats	—	3.20	0.312
Aluminum Paint (Varnish vehicle)			
On Celotex insulating lath, one coat	—	18.2	0.055
On Celotex insulating lath, two coats	—	0.73	1.373
On Homosote, one coat	—	66.6	0.015
On Homosote, two coats	—	0.0	∞
On Pine, one coat	—	7.15	0.14
On Pine, two coats	—	1.07	0.93
On Pine, three coats	—	0.80	1.25
On Plaster, two coats	—	3.58	0.279
On Plaster, three coats	—	1.85	0.541
Asphalt			
On Concrete, two coats	—	29.4	0.034
Enamel, white (Varnish vehicle)			
On Pine, one coat	—	9.10	0.11
On Pine, two coats	—	2.54	0.39
On Pine, three coats	—	1.85	0.54
On Plaster, two coats	—	2.76	0.362
On Plaster, three coats	—	2.16	0.463
Flat white			
On Cedar, three coats	—	4.67	0.214
On Plywood, two coats	—	8.48	0.118
Flat Interior, white (Linseed Rosin Vehicle)			
On Plaster, two coats	—	5.20	0.192
On Plaster, three coats	—	3.65	0.274
Flat Interior, white (Rosin Perrilla Oil Vehicle)			
On Plaster, two coats	—	2.38	0.42
On Plaster, three coats	—	2.47	0.404
Interior-Exterior Paint (Linseed Vehicle)			
On Plaster, two coats	—	7.00	0.143
On Plaster, three coats	—	2.33	0.428
Seal Coat, white (Varnish Vehicle)			
On Plaster, two coats	—	3.77	0.365
On Plaster, three coats	—	2.29	0.436
Semi-gloss Interior, white (Lins. Tung Vehicle)			
On Plaster, two coats	—	5.02	0.199
On Plaster, three coats	—	3.56	0.281
Manufactured Boards			
Fiberboard			
Plain	1.06	38.0	0.026
Plain	0.83	43.4	0.022
Plain	0.599	56.4	0.018
Plain	0.492	60.6	0.016
Plain	0.405	74.5	0.013
Plain	0.201	133.2	0.007
Dipped asphalt one surface	0.633	17.3	0.058
Rolled asphalt one surface	0.492	8.0	0.125
Two ½ in. samples joined with asphalt	0.985	2.74	0.365
Laminated, 6 layers fiberboard, 5 of asphalt	0.527	0.231	4.32
Johns-Manville Flexboard	0.125	11.8	0.085
Masonite			
Presdwood (Tempered)	0.13	9.75	0.103
Presdwood	0.13	21.7	0.046
5 thicknesses	—	6.25	0.16
7 thicknesses	—	4.80	0.208
Plasterboard			
Plaster between paper	0.37	70.3	0.014
Plywood			
Douglas Fir (G25)	0.25	7.48 - 9.07	0.11 - 0.134
	0.375	9.2	0.109
with two coats white lead paint	0.25	3.96	0.252
Miscellaneous			
Ground cornstalks	2.0	85.5	0.0117
Hole (1/16 in.) in sheet metal	—	0.85	1.17
Metal, sheets	—	0.0	∞
Water surface, free standing	—	1238.0	0.0008

*Note: All weights in Col. 1 are in pounds per 100 sq. ft.

(Table concluded on Sheet 243)

†Compiled from reports of various investigators, including those of J. D. Babbitt of the National Research Laboratories, Ottawa, Canada; F. B. Rowley, A. B. Algren and C. E. Lund of the engineering Experiment Station, University of Minnesota, Minneapolis, Minn.; and H. J. Barre of the Agricultural Experiment Station, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

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ESTIMATING WATER VAPOR TRANSMISSION THROUGH WALLS

TABLE 1. *(Concluded)* WATER VAPOR TRANSMITTED THROUGH VARIOUS BUILDING MATERIALS†

Material*	Thickness, Inches	Permeability: Grains per Sq Ft per Hr per Lb per Sq In Vapor Pressure Difference	Vapor Resistance (Reciprocal of Permeability)
Paper			
Asbestos			
14 lb	0.28	321.0	0.003
Asphalt Coated Kraft (not saturated)			
Heavy, 4.8 lb	0.013	0.83 - 1.51	0.66 - 1.2
Asphalt Saturated and Coated Kraft			
9 lb	0.013-0.018	0.38 - 0.99	1.01 - 2.64
Asphalt Saturated Sheathing			
No. 2, 6.25 lb	0.015-0.017	0.29 - 32.7	0.03 - 3.45
Renown, 6.25 lb	0.017	8.50	0.118
Kraft, 6.25 lb	0.015	3.14	0.32
Kraft			
1 sheet	0.004	159.5	0.006
2 sheets	—	101.5	0.01
3 sheets	—	76.0	0.013
4 sheets	—	60.4	0.016
5 sheets	—	50.8 - 61.8	0.16 - 0.02
7 sheets	—	36.3 - 43.1	0.222- 0.027
8 sheets	—	31.4 - 36.3	0.275- 0.032
Kraft (Waxed)			
Light, 2 lb	0.003-0.004	0.216- 2.43	0.412- 4.63
Medium, 2.8 lb	0.005-0.006	0.31 - 0.74	1.35 - 3.22
Heavy, 4 lb	0.007	1.11 - 9.9	0.1 - 0.9
Kraft (Asphalt Infused)			
Waxed, ribbed, one surface infused	0.006	1.05	0.95
Waxed, ribbed, one surface infused	0.007	1.05	0.95
Waxed, one surface infused	0.009	0.89	1.12
Unwaxed, one surface infused	0.005	1.66	0.6
Red Rosin Sheathing			
Plain	—	123.1	0.008
Roofing			
Base Sheet, 39 lb	0.076	0.71	1.42
Cap Sheet, 39 lb	0.080	0.15	6.66
Janus, light, 32 lb	0.052	0.18	5.55
Janus, medium, 42 lb	0.066	0.15	6.66
Janus, heavy, 51 lb	0.073	0.12	8.34
Janus, extra heavy, 60 lb	0.105	0.18	5.55
Janus, super heavy, 69 lb	0.115	0.06	16.7
Talisman, medium, 42 lb	0.073	0.12	8.34
Talisman, heavy, 51 lb	0.088	0.12	8.34
Talisman, extra heavy, 60 lb	0.109	0.28	3.57
Talisman, super heavy, 69 lb	0.126	0.22	4.55
Tar Saturated Sheathing			
No. 2, 6.25 lb	0.016-0.018	20.2 - 46.2	0.216- 0.05
11 lb	0.032-0.040	25.0 - 37.9	0.264- 0.04
12.5 lb	0.031	50.8	0.02
Waxed			
Light, 2 lb	0.004	0.25 - 2.28	4.0 - 0.438
Medium, 2.8 lb	0.005-0.006	0.83 - 5.54	0.18 - 1.19
Heavy, 4 lb	0.007-0.008	2.71 - 6.65	0.15 - 0.37
Insulation			
Loose			
Rockwool	1.0	51.9 -468.0	0.002- 0.019
Board			
Celotex insulating lath	0.50	58.1	0.017
with one coat aluminum paint	0.50	13.9	0.072
with two coats aluminum paint	0.50	0.72	1.39
Celotex vapor seal sheathing	0.78	3.99	0.25
Homosote	0.50	38.8	0.026
with one coat aluminum paint	0.50	24.6	0.041
with two coats aluminum paint	0.50	0.0	∞
Johns-Manville rock cork	0.523	6.02	0.166
	0.984	4.95	0.202
	2.001	4.08	0.245
Nu-wood	0.50	86.3	0.015
Pressed corkboard	0.905-0.985	4.74 - 5.42	0.21 - 0.184

*Note: All weights in Col. 1 are in pounds per 100 sq ft.

†Compiled from reports of various investigators, including those of J. D. Babbitt of the National Research Laboratories, Ottawa, Canada; F. B. Rowley, A. B. Algren and C. E. Lund of the Engineering Experiment Station, University of Minnesota, Minneapolis, Minn.; and H. J. Barre of the Agricultural Experiment Station, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

It is important to note that a small crack or the occasional opening of doors may result in the transmission of a greater amount of moisture than would normally pass through a large area of wall space. Use of these data without taking into account the tremendous loss through cracks and open spaces may result in errors as high as 300%.

Table 1, concluded on this sheet from H&V's Reference Data 241-242, together with the tables on the other side of this sheet are suggested for use in calculating the quantity of moisture transmitted between spaces separated by simple or compound walls of the materials covered by the tables, and where the relative humidities are not over 75%. The data in the tables are those of

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H. & V.'s REFERENCE DATA—243

ESTIMATING WATER VAPOR TRANSMISSION THROUGH WALLS

TABLE 2—WATER VAPOR TRANSMITTED THROUGH SLITS IN VAPOR BARRIERS

Width of Slit, Inches	Aluminum Foil Between Two Sheets of ⅜ In. Plasterboard	Aluminum Foil Between Two Sheets of ½ In. Fiberboard	Aluminum Foil Backing on ⅜ In. Plasterboard Sheet	Aluminum Foil Backing on ⅜ In. Plasterboard Sheet and ½ In. Plaster
	Moisture Transmitted Gr. per Hr per Lineal In. of Crack per Lb per Sq In. Vapor Pressure Difference			
0.02	0.142	0.203	0.219	0.110
0.04	0.169	0.234	0.254	0.126
0.06	0.189	0.256	0.280	0.137
0.08	0.208	0.276	0.302	0.147
0.10	0.225	0.292	0.322	0.156
0.12	0.241	0.308	0.340	0.164
0.14	0.257	0.322	0.357	0.171
0.16	0.272	0.336	0.373	0.178
0.18	0.287	0.348	0.388	0.184
0.20	0.302	0.360	0.403	0.190
0.22	0.316	0.372	0.418	0.196
0.24	0.332	0.384	0.433	0.202
0.26	0.347	0.396	0.447	0.208
0.28	0.362	0.407	0.460	0.213
0.30	0.377	0.419	0.475	0.218

Babbitt (National Research Council, Canada), Barre (Iowa State), and Rowley et al (Univ. of Minnesota). Variation in coefficients is due to differences among samples and among test methods.

Tables 1 and 2 are used in the same manner as heat transmission conductivity tables. Resistances given in Table 1 can be combined by the formula

$$M = \frac{1}{R_1 + R_2 + R_3 + \ldots\ldots R_n}$$

where M is the amount of moisture transmitted through a unit area of the wall and R_1, R_2, etc., are the resistances of the separate materials making up the wall.

Where the resistance listed in Table 1 is not for the thickness desired, determine the desired resistance by multiplying the given resistance by the thickness desired and dividing the result by the thickness given in the table.

The formula for the amount of water vapor transmitted through a wall is

$$W = MA\,(P_1 - P_2)$$

where W is the total water vapor flow in grains in one hour across the wall, M the moisture transmission coefficient, A the area of wall in square feet, P_1 the vapor pressure on one side and P_2 the vapor pressure on the other side, both in pounds per square inch.

Table 2, from Babbitt, is for estimating moisture flow through slits where materials are joined, and can be used, with discretion, for door cracks.

To determine vapor pressures and differences use a psychrometric table or Table 3. Figures in Table 3 are for 100% R.H.; for other values of R.H. multiply figures in Table 3 by the desired relative humidity. The following example shows how the data can be used:

Problem: Estimate the quantity of water vapor transmitted through a wall of a space at 70F and 10% R.H. when the space outside is at 90F and 50% R.H.; the wall is 100 sq ft in area and made of two thicknesses of Flexboard with a 2 inch space between filled with J-M rock cork.

TABLE 3—VAPOR PRESSURE OF WATER VAPOR IN AIR

Dry Bulb Temperature, F	Vapor Pressure, Lb per Sq In.	Dry Bulb Temperature, F	Vapor Pressure, Lb per Sq In.
—20	0.0062	72	0.389
—15	0.0082	73	0.401
—10	0.0108	74	0.415
— 5	0.0142	75	0.429
0	0.0185	76	0.444
5	0.0240	78	0.475
10	0.0310	80	0.506
15	0.0397	85	0.606
20	0.0505	90	0.698
25	0.0641	95	0.815
30	0.0809	100	0.948
32	0.0885	105	1.100
35	0.1000	110	1.274
40	0.1220	115	1.470
45	0.1478	120	1.693
50	0.1785	125	1.940
55	0.2143	130	2.17
60	0.2564	135	2.54
62	0.276	140	2.88
64	0.296	145	3.28
65	0.306	150	3.72
66	0.317	155	4.20
67	0.328	160	4.74
68	0.340	170	5.99
69	0.352	180	7.50
70	0.363	190	9.33
71	0.375	200	11.55

SOLUTION: See Table 3. At 70F, 10% R.H., the vapor pressure is .363 × .10 = .0363. At 90F and 50% R.H., .698 × .50 = .349. Pressure difference is .349 — .036 = .313. See Table 1. The resistance of rock cork is .166 per .523 in., so that for 2 inches it is (.166 × 2) ÷ .523 = .635. For the boards, each has a resistance of .085. Sum of resistances is .085 + .085 + .635 = .805, so that unit moisture transmitted (M) is 1/.805 = 1.24. Total flow W is 1.24 × 100 × .313 = 38.9 grains per hour.

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THICKNESS OF INSULATION REQUIRED TO PREVENT SWEATING ON COLD PIPES

The purpose of this sheet is to enable the user to determine the proper thickness of insulation to provide against the sweating of cold pipe lines. Table 1 gives the necessary thickness for four fluid temperatures for three different conductivities of insulation and for a variety of pipe sizes and combinations of air temperature and humidity. Thicknesses so determined are minimum, or barely sufficient. Table 2 gives the k value for common insulators for entering Table 1. Interpolation in Table 1 can be employed without serious error. Use of tables is illustrated by following:

Problem: What thickness of molded rockwool insulation will be necessary to provide anti-sweat protection to a 2 in. pipe line carrying 20F brine when the surrounding air temperature is 90F and the relative humidity 70%?

Solution: Table 2 shows k for molded rockwool to be .025 to .027. Use .026. Table 1 then gives, for 20F brine, 2 in. pipe, air at 90F temperature and 70% relative humidity, and for a k value of .024, a required minimum thickness of 1.60 in. For a k value of .029, the thickness is 1.85 in. Interpolation shows the thickness for rockwool with a k value of .026 to lie 2/5 of the way between 1.60 and 1.85, or 1.70 in.

TABLE 1.

Liquid Temperature	Pipe Size, In.	k*	Air Temperature, F														
			60			70			80			90			100		
			Relative Humidity, %														
			50	70	90	50	70	90	50	70	90	50	70	90	50	70	90
			Thickness of Insulation, In.														
0F	½	.024	.65	1.26	3.55	.73	1.41	3.87	.83	1.51	4.17	.89	1.64	4.50	.95	1.72	4.71
		.029	.74	1.43	4.03	.84	1.59	4.35	.94	1.72	4.75	1.00	1.85	5.08	1.10	1.93	5.13
		.034	.82	1.63	4.62	.95	1.81	4.96	1.06	1.96	5.38	1.15	2.09	5.76	1.22	2.20	6.01
	¾	.024	.69	1.33	3.80	.79	1.44	4.08	.87	1.60	4.43	.94	1.73	4.78	1.01	1.82	4.94
		.029	.78	1.51	4.27	.89	1.68	4.58	.98	1.80	5.00	1.06	1.95	5.37	1.14	2.06	5.57
		.034	.89	1.71	4.84	1.01	1.90	5.21	1.11	2.04	5.68	1.21	2.21	6.10	1.28	2.33	6.3
	1	.024	.71	1.40	3.98	.82	1.56	4.29	.92	1.67	4.68	.98	1.80	4.99	1.05	1.90	5.23
		029	.81	1.57	4.50	.92	1.74	4.83	1.02	1.88	5.24	1.11	2.04	5.61	1.12	2.16	5.83
		.034	.94	1.79	5.09	1.05	2.01	5.47	1.16	2.14	5.99	1.26	2.32	6.37	1.36	2.44	6.64
	1¼	.024	.73	1.47	4.21	.85	1.64	4.52	.95	1.77	4.89	1.03	1.90	5.26	1.11	2.01	5.47
		.029	.84	1.69	4.74	.97	1.84	5.10	1.10	1.98	5.54	1.16	2.13	5.93	1.25	2.27	7.17
		.034	.97	1.88	5.38	1.11	2.10	5.78	1.21	2.26	6.27	1.32	2.43	6.71	1.42	2.57	6.97
	1½	.024	.75	1.52	4.35	.87	1.63	4.67	.96	1.81	4.86	1.06	1.97	5.43	1.13	2.08	5.67
		.029	.86	1.70	4.90	.99	1.91	5.27	1.09	2.06	5.70	1.19	2.22	6.11	1.28	2.38	6.36
		.034	.98	1.96	5.55	1.12	2.18	5.97	1.27	2.33	6.48	1.38	2.50	6.95	1.50	2.65	7.21
	2	.024	.77	1.59	4.56	.89	1.77	4.90	.99	1.91	5.32	1.09	2.05	5.72	1.17	2.17	5.93
		.029	.89	1.79	5.13	1.00	1.99	5.51	1.13	2.14	5.98	1.22	2.32	6.43	1.33	2.44	6.68
		.034	1.00	2.03	5.82	1.16	2.26	6.26	1.30	2.45	6.78	1.41	2.63	7.29	1.51	2.78	7.57
	3	.024	.82	1.68	4.95	.96	1.89	5.31	1.05	2.05	5.79	1.14	2.21	6.20	1.23	2.36	6.44
		.029	.96	1.85	5.61	1.11	2.17	6.04	1.22	2.36	6.55	1.31	2.53	7.04	1.43	2.67	7.30
		.034	1.08	2.20	6.33	1.24	2.48	6.82	1.37	2.68	7.41	1.49	2.85	7.97	1.61	3.03	8.25
	4	.024	.84	1.73	5.24	.97	1.96	5.60	1.08	2.09	6.12	1.24	2.31	6.57	1.26	2.48	6.78
		.029	.97	1.95	5.91	1.13	2.22	6.31	1.26	2.43	6.90	1.35	2.65	7.45	1.46	2.79	7.69
		.034	1.12	2.27	6.68	1.30	2.56	7.22	1.40	2.81	7.84	1.58	3.03	8.40	1.66	3.22	8.86
	5	.024	.85	1.81	5.51	1.03	2.00	5.91	1.17	2.20	6.43	1.25	2.59	6.90	1.33	2.53	7.15
		.029	1.00	2.06	6.23	1.14	2.31	6.67	1.28	2.48	7.23	1.39	3.06	7.87	1.50	2.87	8.07
		.034	1.17	2.36	7.03	1.33	2.67	7.57	1.48	2.89	8.22	1.61	3.13	8.82	1.73	3.31	9.18
20F	½	.024	.38	.86	2.58	.50	1.02	2.94	.61	1.17	3.32	.69	1.29	3.66	.75	1.47	3.91
		.029	.43	.97	2.91	.58	1.12	3.31	.67	1.32	3.73	.77	1.46	4.12	.86	1.60	4.33
		.034	.50	1.09	3.30	.64	1.33	3.76	.77	1.49	4.34	.88	1.66	4.71	.97	1.81	5.00
	¾	.024	.39	.90	2.72	.53	1.09	3.07	.63	1.23	3.51	.73	1.37	3.88	.80	1.49	4.13
		.029	.44	1.03	3.07	.60	1.23	3.59	.72	1.40	4.04	.81	1.54	4.46	.91	1.68	4.62
		.034	.53	1.16	3.49	.67	1.40	3.96	.81	1.57	4.47	.93	1.75	4.94	1.03	1.91	5.26
	1	.024	.41	.96	2.86	.54	1.13	3.24	.65	1.29	3.63	.75	1.44	4.07	.83	1.56	4.33
		.029	.46	1.06	3.23	.60	1.29	3.66	.75	1.45	4.15	.84	1.61	4.60	.95	1.76	4.87
		.034	.55	1.21	3.65	.69	1.45	4.15	.84	1.66	4.71	.97	1.82	5.20	1.06	2.00	5.52
	1¼	.024	.43	.98	3.01	.57	1.19	3.42	.66	1.36	3.89	.77	1.49	4.29	.86	1.65	4.58
		.029	.47	1.12	3.40	.62	1.34	3.87	.76	1.54	4.36	.87	1.71	4.85	.99	1.85	5.16
		.034	.56	1.27	3.85	.72	1.52	4.38	.87	1.74	4.96	1.00	1.92	5.45	1.12	2.10	5.84
	1½	.024	.43	1.00	3.10	.57	1.21	3.53	.67	1.39	4.00	.79	1.53	4.43	.88	1.73	4.71
		.029	.49	1.14	3.50	.66	1.39	3.98	.77	1.57	4.51	.88	1.74	4.99	1.00	1.92	5.31
		.034	.56	1.32	3.97	.73	1.58	4.52	.89	1.79	5.14	1.03	1.99	5.65	1.16	2.18	6.04
	2	.024	.44	1.03	3.26	.58	1.33	3.70	.70	1.46	4.20	.83	1.60	4.65	.91	1.79	4.96
		.029	.49	1.17	3.65	.66	1.43	4.19	.80	1.66	4.74	.92	1.85	5.24	1.03	2.01	5.59
		.034	.57	1.35	4.17	.74	1.66	4.74	.91	1.87	5.37	1.06	2.07	5.94	1.18	2.28	6.32
	3	.024	.44	1.09	3.55	.58	1.35	4.02	.71	1.52	4.55	.84	1.69	5.04	.96	1.89	5.37
		.029	.49	1.24	4.01	.68	1.52	4.55	.84	1.75	5.35	.98	1.96	5.74	1.09	2.17	6.10
		.034	.60	1.45	4.55	.82	1.73	5.15	.98	1.99	5.85	1.10	2.24	6.47	1.26	2.50	6.91
	4	.024	.45	1.13	3.71	.58	1.39	4.25	.71	1.58	4.84	.88	1.78	5.37	.99	1.96	5.67
		.029	.52	1.29	4.23	.68	1.60	4.84	.85	1.85	5.47	1.01	2.05	6.03	1.19	2.23	6.46
		.034	.60	1.51	4.79	.83	1.85	5.45	1.01	2.07	6.18	1.17	2.32	6.84	1.29	2.57	7.31
	5	.024	.47	1.17	3.92	.58	1.44	4.48	.72	1.59	5.06	.88	1.87	5.62	1.03	2.00	6.01
		.029	.56	1.33	4.45	.70	1.64	5.03	.86	1.89	5.73	1.06	2.08	6.33	1.17	2.33	6.72
		.034	.60	1.55	5.03	.84	1.89	5.72	1.03	2.14	6.42	1.20	2.42	7.16	1.36	2.70	7.72

*Btu per hr per sq ft per F per ft of thickness.

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H. & V.'s REFERENCE DATA—245

THICKNESS OF INSULATION REQUIRED TO PREVENT SWEATING ON COLD PIPES

TABLE 1 (Continued)

Liquid Temperature	Pipe Size, In.	k*	Air Temperature, F: 60			70			80			90			100		
			Relative Humidity, %: 50	70	90	50	70	90	50	70	90	50	70	90	50	70	90
			Thickness of Insulation, In.														
35F	½	.024	.12	.50	1.72	.28	.71	2.18	.40	.88	2.62	.51	1.04	3.02	.60	1.16	3.30
		.029	.15	.56	1.94	.32	.80	2.46	.46	.99	2.96	.58	1.17	3.40	.67	1.32	3.71
		.034	.18	.65	2.21	.37	.91	2.80	.53	1.08	3.35	.66	1.33	3.87	.77	1.50	4.22
	¾	.024	.12	.52	1.82	.29	.75	2.31	.42	.93	2.77	.52	1.10	3.19	.62	1.23	3.49
		.029	.15	.59	2.06	.34	.85	2.60	.48	1.06	3.12	.60	1.23	3.59	.72	1.39	3.93
		.034	.18	.67	2.32	.38	.96	2.95	.55	1.19	3.54	.69	1.41	4.08	.82	1.58	4.45
	1	.024	.12	.52	1.91	.29	.77	2.41	.42	.95	2.90	.54	1.14	3.34	.63	1.29	3.80
		.029	.15	.59	2.15	.35	.88	2.71	.48	1.09	3.27	.62	1.29	3.91	.73	1.45	4.26
		.034	.18	.69	2.44	.40	1.01	3.10	.56	1.24	3.85	.70	1.46	4.42	.84	1.66	4.82
	1¼	.024	.13	.54	2.01	.31	.81	2.54	.44	1.01	3.05	.57	1.21	3.52	.66	1.35	3.85
		.029	.16	.62	2.27	.35	.92	2.86	.51	1.15	3.45	.63	1.36	3.97	.76	1.53	4.35
		.034	.18	.71	2.56	.43	1.05	3.26	.58	1.30	3.93	.74	1.53	4.49	.87	1.74	4.92
	1½	.024	.13	.56	2.10	.31	.81	2.61	.46	1.05	3.16	.57	1.25	3.65	.68	1.40	3.96
		.029	.16	.64	2.35	.35	.93	2.95	.51	1.18	3.55	.66	1.40	4.09	.78	1.59	4.48
		.034	.19	.73	2.65	.42	1.08	3.36	.59	1.36	4.04	.74	1.60	4.65	.90	1.80	5.11
	2	.024	.14	.57	2.16	.31	.84	2.75	.47	1.06	3.32	.59	1.27	3.82	.70	1.45	4.16
		.029	.16	.66	2.45	.35	.96	3.11	.53	1.22	3.74	.67	1.46	4.29	.79	1.67	4.71
		.034	.19	.74	2.79	.44	1.09	3.51	.61	1.39	4.23	.77	1.67	4.88	.91	1.87	5.35
	3	.024	.14	.58	2.36	.33	.91	2.99	.47	1.08	3.61	.61	1.33	4.15	.70	1.56	4.54
		.029	.18	.70	2.66	.37	1.03	3.38	.53	1.30	3.73	.70	1.56	4.69	.84	1.77	5.13
		.034	.19	.77	3.02	.44	1.17	3.85	.62	1.47	4.61	.82	1.77	5.31	.98	2.00	5.81
	4	.024	.14	.59	2.47	.33	.95	3.12	.47	1.15	3.81	.62	1.39	4.41	.70	1.60	4.84
		.029	.20	.68	2.79	.38	1.06	3.55	.56	1.33	4.30	.71	1.58	4.96	.84	1.82	5.42
		.034	.20	.80	3.21	.45	1.23	4.04	.63	1.55	4.88	.83	1.84	5.53	1.01	2.09	6.12
	5	.024	.14	.59	2.53	.34	.97	3.25	.50	1.23	3.97	.64	1.47	4.58	.72	1.67	5.03
		.029	.20	.70	2.87	.38	1.06	3.76	.56	1.39	4.53	.72	1.64	5.20	.85	1.92	5.71
		.034	.22	.80	3.34	.45	1.25	4.26	.64	1.61	5.08	.84	1.93	5.90	1.03	2.17	6.45
50F	½	.024	0	.01	.70	.01	.33	1.33	.16	.56	1.86	.31	.74	2.32	.42	.90	2.66
		.029	0	.01	.80	.02	.37	1.50	.21	.63	2.10	.35	.85	2.60	.48	1.02	3.00
		.034	0	.01	.92	.02	.43	1.70	.24	72	2.38	41	.96	2.97	.55	1.16	3.40
	¾	.024	0	.01	.76	.01	.35	1.41	.17	.59	1.96	.33	.79	2.54	44	.95	2.81
		.029	0	.01	.85	.02	.40	1.59	.21	.65	2.22	.37	.90	2.76	.50	1.08	3.17
		.034	0	.01	.97	.02	.45	1.80	.24	.77	2.52	.43	1.02	3.13	58	1.18	3.60
	1	.024	0	.01	.79	.01	.34	1.46	.18	.60	2.05	.33	.82	2.57	.46	.99	2.94
		.029	0	.01	.88	.02	.40	1.65	.21	.68	2.31	.38	.94	2.88	.50	1.12	3.31
		.034	0	.01	1.01	.02	.46	1.88	.24	78	2.63	44	1.06	3.28	.58	1.28	5.90
	1¼	.024	0	.01	.81	.02	.37	1.55	.19	.62	2.13	.34	.86	2.70	.47	1.04	3.10
		.029	0	.01	.91	.02	.42	1.75	.22	71	2.43	.39	.98	3.05	.53	1.18	3.50
		.034	0	.01	1.06	.03	.47	1.99	.24	.82	2.77	.46	1.10	3.46	.60	1.35	3.97
	1½	.024	0	.01	.83	.03	.41	1.60	.19	.64	2.23	.35	.87	2.79	.48	1.07	3.20
		.029	0	.01	.93	.03	.43	1.80	.22	.72	2.51	.39	.98	3.14	.53	1.22	3.60
		.034	0	.01	1.07	.03	.50	2.05	.25	.82	2.86	.46	1.14	3.57	.62	1.39	4.10
	2	.024	0	.01	.84	.03	.34	1.67	.19	.66	2.35	.35	.89	2.93	.48	1.13	3.36
		.029	0	.01	.97	.03	.44	1.87	.23	.74	2.63	.40	1.03	3.30	.55	1.24	3.77
		.034	0	.01	1.12	.04	.50	2.13	.25	.85	2.98	.47	1.17	3.75	.63	1.42	4.28
	3	.024	0	.01	.91	.03	.36	1.75	.19	.68	2.56	.35	.96	3.15	.49	1.17	3.66
		.029	0	.01	1.05	.03	.44	2.05	.23	.79	2.87	.40	1.09	3.58	.56	1.31	4.13
		.034	0	.01	1.19	.04	.49	2.32	.26	.91	3.28	.47	1.24	3.94	.67	1.52	4.68
	4	.024	0	.01	.95	.03	.36	1.87	.20	.68	2.65	.36	.97	3.37	.49	1.24	3.87
		.029	0	.01	1.09	.03	.44	2.12	.22	.79	3.04	.43	1.12	3.80	.56	1.40	4.34
		.034	0	.01	1.24	.04	.52	2.43	.27	.95	3.44	.47	1.30	4.30	.68	1.62	4.95
	5	.024	0	.01	.97	.04	.36	1.93	.22	.70	2.73	.36	1.03	3.47	.50	1.25	4.04
		.029	0	.01	1.11	.04	.44	2.17	.25	.80	3.14	.45	1.14	3.98	.58	1.45	4.56
		.034	0	.01	1.25	.04	.56	2.50	.28	.97	3.64	.50	1.33	4.51	.70	1.67	5.23

*Btu per hr per sq ft per F per ft of thickness.

TABLE 2.—THERMAL CONDUCTIVITY (K) OF PIPE INSULATORS

Material	Density, Lb. per Cu. Ft.	Thermal Conductivity, k, B.t.u. per Sq. Ft. per Hour per Ft. Thick per F
Cork[a]	7.5	.021—.024
Cork[a]	8.1	.026
Cork[a]	12.5	.030—.034
Flaxlinum[b]	11.2	.028
Glass wool	10	.023
Hair felt	9-17	.023—.029
Rock cork	16	.028
Rock wool[c]	15	.025—.027
Wool felt	8.5	.022—.033
Aluminum foil[d]	—	.028

[a]Regranulated, molded, and baked. [b]With fiberfelt. [c]Molded with binder. [d].00035 in. thick, 7 foils per inch.

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VELOCITY EQUIVALENTS OF GAGE READINGS

h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)
.01	400.5	.51	2,859.0	1.01	4,021.0	1.51	4,921.4
.02	566.3	.52	2,888.4	1.02	4,044.8	1.52	4,937.7
.03	693.7	.53	2,915.6	1.03	4,064.6	1.53	4,953.9
.04	801.0	.54	2,942.9	1.04	4,084.3	1.54	4,970.1
.05	895.5	.55	2,970.1	1.05	4,103.9	1.55	4,986.2
.06	980.8	.56	2,996.9	1.06	4,123.4	1.56	5,002.2
.07	1,059.7	.57	3,023.8	1.07	4,142.8	1.57	5,018.3
.08	1,132.6	.58	3,050.2	1.08	4,162.1	1.58	5,034.2
.09	1,201.5	.59	3,076.2	1.09	4,181.3	1.59	5,050.1
.10	1,266.4	.60	3,102.3	1.10	4,200.5	1.60	5,066.0
.11	1,328.5	.61	3,127.9	1.11	4,219.5	1.61	5,081.8
.12	1,387.3	.62	3,153.5	1.12	4,238.5	1.62	5,097.5
.13	1,444.2	.63	3,178.8	1.13	4,257.4	1.63	5,113.2
.14	1,498.7	.64	3,204.0	1.14	4,276.2	1.64	5,128.9
.15	1,551.1	.65	3,228.8	1.15	4,294.9	1.65	5,144.5
.16	1,602.0	.66	3,253.7	1.16	4,313.5	1.66	5,160.0
.17	1,651.3	.67	3,254.1	1.17	4,332.1	1.67	5,175.5
.18	1,699.3	.68	3,302.5	1.18	4,350.6	1.68	5,191.1
.19	1,745.8	.69	3,327.0	1.19	4,368.9	1.69	5,206.5
.20	1,791.0	.70	3,351.0	1.20	4,387.3	1.70	5,221.9
.21	1,835.5	.71	3,374.6	1.21	4,405.5	1.71	5,237.2
.22	1,870.3	.72	3,398.2	1.22	4,423.7	1.72	5,252.5
.23	1,920.8	.73	3,421.9	1.23	4,441.7	1.73	5,267.7
.24	1,962.0	.74	3,445.1	1.24	4,459.8	1.74	5,283.0
.25	2,002.5	.75	3,468.3	1.25	4,477.7	1.75	5,298.1
.26	2,042.1	.76	3,491.6	1.26	4,495.6	1.76	5,313.2
.27	2,081.0	.77	3,514.4	1.27	4,513.4	1.77	5,328.3
.28	2,119.4	.78	3,537.2	1.28	4,531.1	1.78	5,343.4
.29	2,156.7	.79	3,559.6	1.29	4,548.8	1.79	5,358.3
.30	2,193.5	.80	3,582.1	1.30	4,566.4	1.80	5,373.3
.31	2,230.0	.81	3,604.5	1.31	4,583.9	1.81	5,388.2
.32	2,265.6	.82	3,626.5	1.32	4,601.4	1.82	5,403.0
.33	2,300.9	.83	3,648.6	1.33	4,618.8	1.83	5,417.8
.34	2,335.3	.84	3,670.6	1.34	4,636.1	1.84	5,432.7
.35	2,369.4	.85	3,692.6	1.35	4,653.4	1.85	5,447.4
.36	2,403.0	.86	3,714.2	1.36	4,670.6	1.86	5,462.1
.37	2,436.2	.87	3,735.5	1.37	4,687.7	1.87	5,476.8
.38	2,468.7	.88	3,757.1	1.38	4,704.8	1.88	5,491.4
.39	2,573.2	.89	3,778.3	1.39	4,721.8	1.89	5,506.0
.40	2,533.2	.90	3,799.5	1.40	4,738.8	1.90	5,520.5
.41	2,564.4	.91	3,820.4	1.41	4,755.7	1.91	5,535.0
.42	2,595.6	.92	3,841.6	1.42	4,772.5	1.92	5,549.5
.43	2,626.1	.93	3,862.4	1.43	4,789.3	1.93	5,563.9
.44	2,656.5	.94	3,882.8	1.44	4,806.0	1.94	5,578.3
.45	2,686.6	.95	3,903.7	1.45	4,822.7	1.95	5,592.7
.46	2,716.2	.96	3,924.1	1.46	4,839.2	1.96	5,607.0
.47	2,745.8	.97	3,944.5	1.47	4,855.8	1.97	5,621.3
.48	2,774.7	.98	3,964.5	1.48	4,872.3	1.98	5,635.5
.49	2,803.5	.99	3,985.0	1.49	4,888.7	1.99	5,649.7
.50	2,831.9	1.00	4,005.0	1.50	4,905.1	2.00	5,663.9

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VELOCITY EQUIVALENTS OF GAGE READINGS

h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)	h (Inches of Water)	v (Air Velocity, Ft. per Min.)
2.01	5,678.0	2.51	6,345.1	3.01	6,948.4	3.51	7,503.4
2.02	5,692.2	2.52	6,357.7	3.02	6,959.9	3.52	7,514.1
2.03	5,706.2	2.53	6,370.4	3.03	6,971.5	3.53	7,524.7
2.04	5,720.3	2.54	6,382.9	3.04	6,983.0	3.54	7,535.4
2.05	5,734.3	2.55	6,395.5	3.05	6,994.4	3.55	7,546.0
2.06	5,748.3	2.56	6,408.0	3.06	7,005.9	3.56	7,556.6
2.07	5,762.2	2.57	6,420.5	3.07	7,017.3	3.57	7,567.2
2.08	5,776.1	2.58	6,433.0	3.08	7,028.7	3.58	7,577.8
2.09	5,789.9	2.59	6,445.4	3.09	7,040.1	3.59	7,588.4
2.10	5,803.8	2.60	6,457.9	3.10	7,051.5	3.60	7,599.0
2.11	5,817.6	2.61	6,470.3	3.11	7,062.9	3.61	7,609.5
2.12	5,831.4	2.62	6,482.7	3.12	7,074.2	3.62	7,620.1
2.13	5,845.1	2.63	6,495.0	3.13	7,085.6	3.63	7,630.6
2.14	5,858.8	2.64	6,507.4	3.14	7,096.9	3.64	7,641.1
2.15	5,872.5	2.65	6,519.7	3.15	7,108.2	3.65	7,651.6
2.16	5,886.1	2.66	6,532.0	3.16	7,119.4	3.66	7,662.0
2.17	5,899.7	2.67	6,544.2	3.17	7,130.7	3.67	7,672.5
2.18	5,913.3	2.68	6,556.5	3.18	7,142.0	3.68	7,682.9
2.19	5,926.8	2.69	6,568.7	3.19	7,153.2	3.69	7,693.4
2.20	5,940.4	2.70	6,580.9	3.20	7,164.3	3.70	7,703.8
2.21	5,953.9	2.71	6,593.1	3.21	7,175.6	3.71	7,714.2
2.22	5,967.3	2.72	6,605.2	3.22	7,186.7	3.72	7,724.6
2.23	5,980.7	2.73	6,617.3	3.23	7,197.9	3.73	7,734.9
2.24	5,994.1	2.74	6,629.4	3.24	7,209.0	3.74	7,745.3
2.25	6,007.5	2.75	6,641.5	3.25	7,220.1	3.75	7,755.6
2.26	6,020.8	2.76	6,653.6	3.26	7,231.2	3.76	7,766.0
2.27	6,034.1	2.77	6,665.6	3.27	7,242.3	3.77	7,776.3
2.28	6,047.4	2.78	6,677.7	3.28	7,253.4	3.78	7,786.6
2.29	6,060.6	2.79	6,689.7	3.29	7,264.4	3.79	7,796.9
2.30	6,073.9	2.80	6,701.6	3.30	7,275.4	3.80	7,807.2
2.31	6,087.0	2.81	6,713.6	3.31	7,286.5	3.81	7,817.4
2.32	6,100.2	2.82	6,725.6	3.32	7,297.5	3.82	7,827.7
2.33	6,113.4	2.83	6,737.5	3.33	7,308.4	3.83	7,837.9
2.34	6,126.5	2.84	6,749.3	3.34	7,319.4	3.84	7,848.1
2.35	6,139.5	2.85	6,761.2	3.35	7,330.4	3.85	7,858.4
2.36	6,152.6	2.86	6,773.1	3.36	7,341.3	3.86	7,868.6
2.37	6,165.6	2.87	6,784.9	3.37	7,352.2	3.87	7,878.8
2.38	6,178.6	2.88	6,796.7	3.38	7,363.1	3.88	7,888.9
2.39	6,191.6	2.89	6,808.5	3.39	7,374.0	3.89	7,899.1
2.40	6,204.5	2.90	6,820.3	3.40	7,384.9	3.90	7,909.2
2.41	6,217.4	2.91	6,832.0	3.41	7,395.7	3.91	7,919.4
2.42	6,230.3	2.92	6,843.7	3.42	7,406.5	3.92	7,929.5
2.43	6,243.2	2.93	6,855.4	3.43	7,417.4	3.93	7,939.6
2.44	6,256.0	2.94	6,867.1	3.44	7,428.1	3.94	7,949.7
2.45	6,268.9	2.95	6,878.8	3.45	7,439.9	3.95	7,959.8
2.46	6,281.6	2.96	6,890.5	3.46	7,449.7	3.96	7,969.8
2.47	6,294.3	2.97	6,902.1	3.47	7,460.5	3.97	7,979.9
2.48	6,307.0	2.98	6,913.7	3.48	7,471.2	3.98	7,989.9
2.49	6,319.8	2.99	6,925.3	3.49	7,481.9	3.99	8,000.0
2.50	6,332.5	3.00	6,936.9	3.50	7,492.7	4.00	8,100.0

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H. & V.'s REFERENCE DATA – 248

HEAT TRANSMISSION TABLES

(Values of U for Walls, Roofs, Floors and Ceilings Using Plywood)

WALLS		A	B	C	D	E
Construction Number	Figures for constructions on this sheet are in B.t.u. per hour per square foot per degree temperature difference, air-to-air, still air inside, 15 m.p.h. wind outside	Thickness of Sheet, Inches				
		1/4	3/8	1/2	5/8	3/4
		U values below				
151	Single Sheet Plywood	.91	.79	.71	.63	.58

	Compound Walls		A	B	C
	Exterior	Interior	Batt or Blanket Insulation between Studs, in.		
152	3/8 in. Plywood	1/4 in. Plywood	.40	.19	.14
153		3/8 in. Plywood	.38	.18*	.13*
154	Shingles or Siding, 5/16 in. Plyscord Sheathing	1/2 in. Fiber Board	.19	.12*	.10*
155	Furred air space between	1/4 in. Plywood	.23	.14*	.11*
156	Shingles or Siding with Plyscord as #155 but with building paper		.29	.16	.12*
157	Shingles or Siding, paper, 1/2 in. Fiber Board	None	.32	—	—
158	Shingles or Siding, building paper	3/8 in. Plywood	.32	.17*	.12*
159	Shingles or Siding, paper, 25/32 in. Shiplap	3/4 in. Wood lath and Plaster	.25	.14	.11*
160	Shingles or Siding, 5/16 in Plyscord Sheathing		.29	.16	.12*
161	Shingles or Siding, 5/16 in. Plyscord Sheathing with furred space between	1/4 in. Plywood	.26	.15	.12
162	Brick veneer, 5/16 in. Plyscord Sheathing, air space between		.25	.16*	.12*

ROOFS		A
163	Shingles on 1 x 4 in. Strips, 2 in. apart on rafters	.46
164	Shingles on Strips (as #164), with Plywood on underside of rafters	.29
165	Composition roofing, 3/8 in. Plyscord Sheathing on rafters	.71
166	Composition roofing (as #165) with Plyscord with 1/4 in. Plywood on underside of rafters	.38
167	Composition roofing (as #166) with Plyscord and Plywood with 1/2 in. batt insulation between	.18

FLOORS AND CEILINGS		A
168	13/16 in. Fir. Floor on 1/2 in. Plyscord sub-floor	.35
169	13/16 in. Fir Floor (as #168) with Plyscord with 1/4 in. Plywood ceiling below joists	.24
170	13/16 in. Fir Floor (as #169) with Plyscord and Plywood with 1/2 in. batt insulation between	.14
171	No floor above, 1/4 in. Plywood ceiling, 1/2 in. batt insulation above	.23
172	1/2 in. Plyscord floor on joists, 1/4 in. Plywood ceiling below	.32
173	1/2 in. Plyscord floor (as #172) with Plywood ceiling with 1/2 in. batt insulation between	.17

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HEAT TRANSMISSION TABLES

(Values of U for Walls, Roofs, Floors and Ceilings Using Plywood)

The table on the other side of this sheet gives the value of U for various types of plywood construction, where U is the amount of heat in Btu passing through 1 sq ft of surface in 1 hr when there is a 1F difference in air temperature between the inside and the outside of the wall, with still air on the inside and a 15 mph wind on the outside.

The value of U is for substitution in the following formula to estimate the amount of heat transmitted through a wall:

$$H = AU\ (t_i - t_o)$$

where H is the total amount of heat in Btu per hour passing through a wall of area A. The temperature of the indoor air is represented by t_i and that of the outdoor air by t_o. Data for the selection of these indoor and outdoor design temperatures are given on H. & V.'s Reference Data 57 and 58.

Most of the values of U which appear on the other side of this sheet are made available through the courtesy of the Douglas Fir Plywood Association, Tacoma, Wash., and are condensed from Section 5 of the Association's loose-leaf data book, "Technical Data on Plywood". Values of U marked with an asterisk have been calculated by HEATING AND VENTILATING from values determined for component parts by the Association.

Resistances (reciprocal of conductivity) for plywood itself, as given by the Association, are as follows: ¼ in. D. F. Plywood, .32; ⅜ in. plywood, .48; ½ in. plywood, .64; ⅝ in. plywood, .80; ¾ in. plywood, .96; ⅜ in. exterior plywood, .48; ½ in. plyscord, .64; 5/16 in. plyscord, .40.

This sheet supplements H. & V.'s Reference Data 69 to 82, inclusive.

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H. & V.'s REFERENCE DATA—250

SPECIFIC HEATS

TABLE 1.—VARIOUS SOLIDS

Material	B.t.u. per Lb. per F.
Aluminum	.22
Andalusite	.17
Antimony	.05
Apatite	.20
Asbestos	.20
Augite	.19
Bakelite, wood filler	.33
Bakelite, asbestos filler	.38
Barite	.11
Barium	.07
Basalt rock	.20
Beryl	.20
Bismuth	.03
Borax	.24
Boron	.31
Cadmium	.06
Calcite, 32-100F	.19
Calcite, 32-212F	.20
Calcium	.15
Carbon	.17
Carborundum	.16
Cassiterite	.09
Cement, dry	.37
Cement, powder	.20
Charcoal	.24
Chalcopyrite	.13
Chromium	.12
Clay	.22
Coal	.26-.37
Cobalt	.11
Concrete, stone	.19
Concrete, cinder	.18
Copper	.09
Corundum	.10
Diamond	.15
Dolomite rock	.22
Fluorite	.22
Fluorspar	.21
Galena	.05
Garnet	.18
Glass, common	.20
Glass, crystal	.12
Glass, plate	.12
Glass wool	.16
Gold	.03
Granite	.19
Hermatite	.16
Hornblende	.20
Hypersthene	.19
Ice, —112F	.35
Ice, —40F	.43
Ice, —4F	.47
Ice, 32F	.49
Iridium	.03
Iron, cast	.12
Iron, wrought	.12
Labradorite	.19
Lava	.20
Lead	.03
Limestone	.22
Magnetite	.16
Magnesium	.25
Malachite	.18
Manganese	.11
Marble	.21
Mercury	.03
Mica	.21
Molybdenum	.06
Nickel	.11
Oligloclose	.21
Orthoclose	.19
Plaster paris	1.14
Platinum	.03
Porcelain	.26
Potassium	.13
Pyrexglass	.20
Pyrolusite	.16
Pyroxylin plastics	.34-.38
Quartz, 55-212F	.19
Quartz, 32F	.17
Rock salt	.22
Rubber	.48
Sandstone	.22
Serpentine	.26
Silk	.33
Silver	.06
Sodium	.30
Steel	.12
Stone	.20
Stoneware	.19
Talc	.21
Tar	.35
Tellurium	.05
Tin	.05
Tile, hollow	.15
Titanium	.14
Topaz	.21
Tungsten	.04
Vanadium	.12
Vulcanite	.33
Wood	.32-.48
Wool	.33
Zinc blend	.11
Zinc	.09

Tables 1 and 2 on this sheet and Tables 3 and 4 on Reference Data 253-254 give the specific heats of a wide variety of substances as collected from numerous sources. Where no temperature is given the specific heat is that at approximately room temperatures.

By definition specific heat is a ratio and consequently not expressed in units. However, the engineer commonly uses the phrase "specific heat" to indicate the quantity of heat necessary to raise a given mass one degree in temperature; this works out satisfactorily numerically

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SPECIFIC HEATS

TABLE 2.—VARIOUS LIQUIDS

Liquid	B.t.u. per Lb. per F.
Alcohol, ethyl, 32F	.55
Alcohol, ethyl, 104F	.65
Alcohol, methyl, 40-50F	.59
Alcohol, methyl, 60-70F	.60
Ammonia, 32F	1.10
Ammonia, 104F	1.16
Ammonia, 176F	1.29
Ammonia, 212F	1.48
Ammonia, 238F	1.61
Anilin	.52
Benzol	.42
Calcium Chloride, sp.gr. 1.20	.73
Castor Oil	.43
Citron Oil	.44
Diphenylamine	.46
Ethyl ether	.53
Fuel oil, sp.gr. .96	.40
Fuel oil, sp.gr. .91	.44
Fuel oil, sp.gr. .86	.45
Fuel oil, sp.gr. .81	.50
Gasoline	.53
Glycerine	.58
Kerosene	.98
Naphthalene	.41
Nitrobenzole	.36
Olive oil	.47
Petroleum	.51
Potassium hydrate	.88
Sea water, sp.gr. 1.0235	.94
Sesame oil	.39
Sodium hydrate	.94
Sodium chloride	.79
Toluol	.36
Turpentine	.41
Water, 20F	1.021
Water, 30F	1.010
Water, 40F	1.005
Water, 50F	1.002
Water, 60F	.995
Water, 70F	.998
Water, 80F	.998
Water, 90F	.997
Water, 100F	.997
Water, 110F	.997
Water, 120F	.997
Water, 130F	.998
Water, 140F	.998
Water, 150F	.999
Water, 160F	1.000
Water, 170F	1.007
Water, 180F	1.002
Water, 190F	1.003
Water, 200F	1.004
Water, 210F	1.005

since in both the English and metric systems the heat quantity to raise 1 lb of water is 1 unit.

It should be noted that the figures are given in most cases to only two decimal places; the data are not believed to be any more accurate than this under a wide temperature range such as that over which the table purports to operate. The figures are believed to be sufficiently accurate for all general engineering work but are not suggested as desirable for highly precise calculations or scientific work.

Table 3 (Reference Data 253-254) gives the specific heats for a fairly large number of foodstuffs. Many of these have been calculated from the formula $S = .008M + .2$ where M is the percentage of moisture in the food. The formula is based on the fact that in practically all types of foodstuffs the average specific heat for the solid material is 0.2. From this the formula given above can be easily deduced.

In calculating Table 3 the percentage of moisture content in various foods is that given in Bulletin 549 of the Department of Agriculture entitled, "Proximate Composition of American Food Materials."

For specific heats of organic and inorganic chemical compounds not here listed the user is referred to the "Handbook of Chemistry and Physics."

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SPECIFIC HEATS

TABLE 3. FOODSTUFFS

Food	Specific Heat, Btu per Lb per F, Above Freezing	Specific Heat, Btu per Lb per F, Below Freezing
Apples	.87	.42
Apricots, fresh	.88	.43
Artichokes	.87	.42
Asparagus	.94	.45
Asparagus beans	.88	.43
Avocados	.72	.37
Bananas	.80	.40
Barracuda	.80	.40
Bass	.82	.41
Beef, carcass	.68	.48
Beef, flank	.56	.32
Beef, loin	.66	.35
Beef, rib	.67	.36
Beef, round	.74	.38
Beef, rump	.62	.34
Beef, shanks	.76	.39
Beef, corner	.63	.34
Beets	.90	.43
Blackberries	.87	.42
Blueberries	.87	.42
Brains	.84	.41
Broccoli	.92	.44
Brussels sprouts	.88	.43
Butter	.30	.24
Butterfish	.77	.39
Cabbage	.94	.45
Candy	.93	—
Carp	.82	.41
Carrots	.91	.44
Cauliflower	.93	.44
Celery	.94	.45
Chard	.93	.44
Cherries, sour	.88	.43
Cherries, sweet	.84	.41
Chicken, squab	.80	.40
Chicken, broilers	.77	.39
Chicken, fryers	.74	.38
Chicken, hens	.65	.35
Chicken, capons	.88	.44
Clams, meat only	.84	.41
Coconut, meat and milk	.68	.36
Coconut, milk only	.95	.45
Codfish	.86	.42
Cod Roe	.76	.39
Cowpeas, fresh	.73	.39
Cowpeas, dry	.28	.22
Crabs	.84	.41
Crab apples	.85	.41
Cranberries	.90	.43
Cream	.90	.38
Cucumber	.97	.45
Currants	.97	.45
Dandelion greens	.88	.43
Dates	.20	.007
Eels	.77	.39
Eggs	.76	.40
Eggplant	.94	.45
Endive	.95	.45
Figs, fresh	.82	.41
Figs, dried	.39	.26
Figs, candied	.37	.26
Flounders	.86	.42
Flour	.38	.28
Frogs legs	.88	.44
Garlic	.79	.40
Gizzards	.78	.39
Goose	.61	.34
Gooseberry	.86	.42
Granadilla	.84	.41
Grapefruit	.91	.44
Grapes	.86	.42
Grape juice	.82	.41
Guavas	.86	.42
Guinea hen	.75	.38
Haddock	.85	.42
Halibut	.80	.40
Herring, smoked	.71	.37
Horseradish, fresh	.79	.40
Horseradish, prepared	.88	.43
Ice cream	.74	.40
Kale	.89	.43
Kidneys	.81	.40
Kidney beans, dried	.28	.23
Kohlrabi	.92	.44
Kumquats	.85	.41
Lamb, carcass	.73	.38
Lamb, leg	.71	.37
Lamb, rib cut	.61	.34
Lamb, shoulder	.67	.35
Lard	.54	.31
Leeks	.91	.44
Lemons	.91	.44
Lemon juice	.92	.44
Lettuce	.96	.45
Lima beans	.73	.38
Limes	.89	.43
Lime juice	.93	.44
Litchi fruits, dried	.39	.26
Lobsters	.82	.41
Loganberries	.86	.42
Loganberry juice	.91	.44
Milk, cow	.90	.47
Mushrooms, fresh	.93	.44
Mushrooms, dried	.30	.23
Muskmelons	.94	.45
Nectarines	.86	.42
Nuts	.28	.24
Olives, green	.80	.40
Onions	.90	.43
Onions, Welsh	.91	.44
Oranges, fresh	.90	.43
Orange juice	.89	.43
Oysters	.84	.41
Peaches, Georgia	.87	.42
Peaches, N. Carolina	.89	.43
Peaches, Maryland	.90	.43
Peaches, New Jersey	.91	.44
Peach juice, fresh	.89	.43
Pears, Bartlett	.89	.43
Pears, Beurre Bosc	.85	.41
Pears, dried	.39	.26
Peas, young	.85	.41
Peas, medium	.81	.40
Peas, old	.88	.43
Peas, split	.28	.23
Peppers, ripe	.91	.44
Perch	.82	.41
Persimmons	.72	.37
Pheasant	.75	.38
Pickerel	.84	.41
Pickles, sweet	.82	.41
Pickles, sour and dill	.96	.45
Pickles, sweet mixed	.78	.29
Pickles, sour mixed	.95	.45
Pig's feet, pickled	.50	.31
Pike	.84	.41
Pineapple, fresh	.88	.43
Pineapple, sliced or crushed	.82	.41
Pineapple juice	.90	.43
Plums	.89	.43
Pomegranate	.85	.41

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H. & V.'s REFERENCE DATA — 253

SPECIFIC HEATS

TABLE 3. (Continued) FOODSTUFFS

Food	Specific Heat, Btu per Lb per F, Above Freezing	Specific Heat, Btu per Lb per F, Below Freezing
Pompano	.77	.39
Porgy	.81	.40
Pork, bacon	.36	.25
Pork, ham	.62	.34
Pork, loin	.66	.35
Pork, shoulder	.59	.33
Pork, spareribs	.62	.34
Pork, smoked ham	.65	.35
Pork, salted	.31	.24
Potatoes	.82	.41
Prickly pears	.91	.43
Prunes	.81	.40
Pumpkin	.92	.44
Quinces	.88	.43
Rabbit	.76	.39
Radishes	.95	.45
Raisins	.39	.26
Raspberries, black	.85	.41
Raspberries, red	.89	.43
Raspberry juice, black	.91	.44
Raspberry juice, red	.93	.44
Reindeer	.73	.37
Rhubarb	.96	.45
Rose Apple	.89	.43
Rutabagas	.91	.44
Salmon	.71	.37
Sand dab, California	.86	.43
Sapodilla	.91	.44
Sapote	.73	.37
Sauerkraut	.93	.44
Sausage, beef and pork	.56	.32
Sausage, bockwurst	.71	.37
Sausage, bologna	.71	.37
Sausage, frankfurt	.69	.36
Sausage, salami	.45	.28
Sardines	.77	.39
Shad	.76	.39
Shrimp	.83	.41
Spanish mackerel	.73	.39
Strawberries	.95	.45
Strawberry juice	.79	.39
String beans	.91	.44
Sturgeon, raw	.83	.41
Sturgeon, smoked	.71	.37
Sugar apple, fresh	.79	.39
Sweet potatoes	.75	.38
Swordfish	.80	.40
Terrapin	.80	.40
Tomatoes, red	.95	.45
Tomatoes, green	.96	.45
Tomato juice	.95	.45
Tongue, beef	.74	.38
Tongue, calf	.79	.40
Tongue, lamb	.76	.38
Tongue, pork	.74	.39
Tongue, sheep	.69	.36
Tripe, beef	.83	.41
Tripe, pickled	.89	.43
Trout	.82	.41
Tuna	.76	.39
Turkey	.67	.35
Turnips	.93	.44
Turtle	.84	.41
Veal, carcass	.74	.38
Veal, flank	.65	.35
Veal, loin	.75	.38
Veal, rib	.73	.37
Veal, shank	.77	.39
Veal, quarter	.74	.38
Venison	.78	.39
Watercress	.95	.45
Watermelons	.94	.45
Whitefish	.76	.39
Yams	.78	.39

TABLE 4. GASES AND VAPORS

Gas or Vapor	Specific Heat. Btu per Lb per F at Constant Pressure	Specific Heat. Btu per Lb per F at Constant Volume
Acetone	.35	—
Air, dry, 50F	.24	.172
Air, dry, 32-392F	.24	.172
Air, dry, 68-824F	.24	.103
Air, dry, 68-1166F	.24	.131
Air, dry, 68-1472F	.24	.172
Air, saturated, 70F	.85	—
Alcohol, C_2H_5OH	.45	.398
Alcohol, CH_3OH	.46	.366
Ammonia	.54	.422
Argon	.12	.072
Benzene, C_6H_6	.33	.236
Bromine	.06	.047
Carbon dioxide	.20	—
Carbon monoxide	.24	.172
Carbon disulphide	.16	.132
Chlorine	.11	.082
Chloroform	.15	.131
Ether	.48	.466
Hydrochloric acid	.19	.136
Hydrogen	3.41	—
Hydrogen sulphide	.25	.189
Methane	.59	.446
Nitrogen	.24	.170
Nitric oxide	.23	.166
Nitrogen tetroxide	1.12	—
Nitrous oxide	.21	.166
Oxygen	.22	—
Steam, 32F	.47	.370
Steam, 212F	.42	.316
Steam, 356F	.51	.389
Sulphur dioxide	.15	.119
Water vapor, 32F	.47	.370
Water vapor, 212F	.42	.316
Water vapor, 356F	.51	.389

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WEATHER DATA FOR NORMAL HEATING SEASON

The accompanying data show the beginning and end of a normal heating season, number of days in the season, and average outside temperature during a normal heating season. These data are abstracted from the "Degree-Day Handbook" (published by The Industrial Press, 148 Lafayette St., New York 13, N. Y.) in which their derivation, advantages, and limitations are fully described. For cities other than those listed in the table below refer to the maps on the reverse side of this sheet.

State and City		Normal Heating Season			
		Number of Days	Begins	Ends	Average Temp.
Ala.	Birmingham	188	Oct 16	Apr 21	52.5
	Mobile	165	Oct 28	Apr 10	56.4
Ariz.	Phoenix	158	Oct 31	Apr 6	56.1
	Yuma	133	Nov 8	Mar 20	58.1
Ark.	Fort Smith	199	Oct 11	Apr 27	49.2
	Little Rock	196	Oct 13	Apr 26	50.6
Cal.	Fresno	206	Oct 14	May 7	53.7
	Los Angeles	230	Oct 19	Jun 5	58.5
	Red Bluff	208	Oct 15	May 10	52.9
	San Diego	262	Oct 6	Jun 24	58.7
	San Francisco	365	.....	.....	56.0
Colo.	Denver	274	Sep 10	Jun 10	43.6
	Pueblo	262	Sep 15	Jun 3	44.0
Conn.	Hartford	272	Sep 9	Jun 7	42.8
	New Haven	271	Sep 11	Jun 8	43.2
Del.	Wilmington	239	Sep 24	May 20	45.0
D. C.	Washington	236	Sep 26	May 19	45.4
Fla.	Jacksonville	143	Nov 6	Mar 28	58.6
	Pensacola	159	Oct 31	Apr 7	57.2
Ga.	Atlanta	201	Oct 10	Apr 28	50.6
	Macon	187	Oct 16	Apr 20	53.3
	Savannah	167	Oct 26	Apr 10	56.1
Ida.	Boise	280	Sep 8	Jun 14	45.2
	Lewiston	272	Sep 10	Jun 8	47.5
Ill.	Chicago	257	Sep 21	Jun 4	41.8
	Peoria	256	Sep 14	May 27	41.1
	Springfield	239	Sep 25	May 20	42.5
Ind.	Evansville	220	Oct 3	May 10	45.7
	Fort Wayne	256	Sep 16	May 29	41.9
	Indianapolis	242	Sep 23	May 22	43.1
Ia.	Davenport	251	Sep 19	May 27	40.0
	Des Moines	251	Sep 19	May 27	39.6
	Dubuque	260	Sep 13	May 30	38.9
Kan.	Topeka	234	Sep 27	May 18	43.8
	Wichita	226	Oct 2	May 15	44.3
Ky.	Lexington	232	Sep 28	May 17	45.1
	Louisville	220	Oct 3	May 10	46.0
La.	New Orleans	144	Nov 4	Mar 27	57.9
	Shreveport	174	Oct 21	Apr 12	53.9
Me.	Bar Harbor	310	Aug 10	Jun 15	40.4
	Portland	304	Aug 25	Jun 24	41.2
Md.	Baltimore	232	Sep 28	May 17	45.5
	Frederick	243	Sep 20	May 20	44.7
Mass.	Boston	273	Sep 10	Jun 9	42.9
	Fitchburg	284	Sep 6	Jun 16	41.7
Mich.	Alpena	327	Aug 12	Jul 4	39.6
	Detroit	268	Sep 12	Jun 6	40.8
	Grand Rapids	269	Sep 10	Jun 5	40.7
	Marquette	339	Aug 9	Jul 13	39.4
Minn.	Minneapolis	275	Sep 6	Jun 7	36.4
	Rochester	284	Aug 30	Jun 9	35.9
Miss.	Meridian	188	Oct 15	Apr 20	53.5
	Vicksburg	174	Oct 21	Apr 12	54.5
Mo.	Kansas City	231	Sep 28	May 16	43.6
	St. Louis	221	Oct 1	May 9	44.3
	Springfield	232	Sep 28	May 17	45.9
Mont.	Butte	365	.....	.....	42.3
	Helena	325	Aug 19	Jul 9	40.7
	Miles City	281	Sep 3	Jun 10	37.4
Neb.	Lincoln	247	Sep 21	May 25	40.7
	North Platte	271	Sep 8	Jun 5	40.8
	Omaha	244	Sep 22	May 23	39.9
Nev.	Las Vegas	204	Oct 8	Apr 29	51.1
	Reno	301	Aug 30	Jun 26	45.4
N. H.	Concord	302	Aug 26	Jun 23	40.7
N. J.	Atlantic City	259	Sep 23	Jun 8	45.0
	Dover	276	Sep 4	Jun 6	42.3
	Newark	249	Sep 20	May 26	43.4
	Phillipsburgh	254	Sep 16	May 27	42.6
	Trenton	244	Sep 23	May 24	44.8
N. M.	Albuquerque	239	Sep 23	May 19	47.0
N. Y.	Albany	267	Sep 10	Jun 3	40.4
	Binghamton	283	Sep 3	Jun 12	41.0
	Buffalo	283	Sep 7	Jun 16	40.9
	New York City	250	Sep 23	May 30	43.6
	Rochester	277	Sep 7	Jun 10	40.7
	Syracuse	273	Sep 5	Jun 4	39.8
N. C.	Charlotte	206	Oct 8	May 1	49.8
	Greensboro	216	Oct 2	May 5	48.7
	Raleigh	207	Oct 8	May 2	49.4
N. D.	Bismarck	298	Aug 26	Jun 19	34.2
	Grand Forks	313	Aug 15	Jun 23	33.8
Ohio	Cincinnati	240	Sep 24	May 21	45.5
	Cleveland	267	Sep 13	Jun 6	42.0
	Columbus	245	Sep 22	May 24	43.0
	Toledo	260	Sep 15	Jun 1	41.6
Okla.	Oklahoma City	210	Oct 9	May 5	47.8
	Tulsa	212	Oct 7	May 6	48.2
Ore.	Baker	328	Aug 17	Jul 10	43.2
	Eugene	330	Aug 17	Jul 12	50.2
	Portland	304	Aug 31	Jun 30	50.3
Pa.	Harrisburg	251	Sep 19	May 27	43.6
	Philadelphia	238	Sep 27	May 22	44.6
	Pittsburgh	245	Sep 21	May 23	43.6
	Scranton	266	Sep 11	Jun 3	42.0
	Uniontown	257	Sep 10	May 24	44.9
R. I.	Providence	280	Sep 7	Jun 13	43.5
S. C.	Charleston	175	Oct 25	Apr 17	54.9
	Columbia	189	Oct 15	Apr 21	52.5
	Greenville	217	Oct 4	May 8	49.4
S. D.	Huron	279	Sep 5	Jun 10	35.7
	Sioux Falls	275	Sep 5	Jun 6	37.2
Tenn.	Chattanooga	205	Oct 9	May 1	49.8
	Knoxville	216	Oct 4	May 7	48.0
	Memphis	195	Oct 13	Apr 25	49.9
Tex.	Amarillo	233	Sep 29	May 19	46.4
	Dallas	181	Oct 18	Apr 16	52.5
	El Paso	191	Oct 13	Apr 21	52.3
	Galveston	138	Nov 10	Mar 27	57.7
Utah	Logan	290	Sep 4	Jun 20	41.7
	Ogden	258	Sep 13	May 28	49.4
	Salt Lake City	267	Sep 15	Jun 8	44.2
Vt.	Burlington	285	Sep 1	Jun 12	38.6
Va.	Charlottesville	238	Sep 17	May 12	47.3
	Norfolk	214	Oct 10	May 11	49.4
	Richmond	220	Oct 3	May 10	48.1
Wash.	Seattle	365	.....	.....	51.4
	Spokane	298	Aug 30	Jun 23	43.7
	Walla Walla	271	Sep 12	Jun 9	47.3
W. Va.	Huntington	235	Sep 24	May 16	44.9
	Parkersburg	238	Sep 24	May 19	45.0
	Wheeling	276	Sep 19	May 21	46.1
Wis.	Beloit	269	Sep 10	Jun 5	39.4
	Madison	273	Sep 8	Jun 7	37.8
	Milwaukee	284	Sep 8	Jun 18	39.5
Wyo	Cheyenne	315	Aug 22	Jul 2	41.3
	Lander	316	Aug 20	Jul 1	38.8

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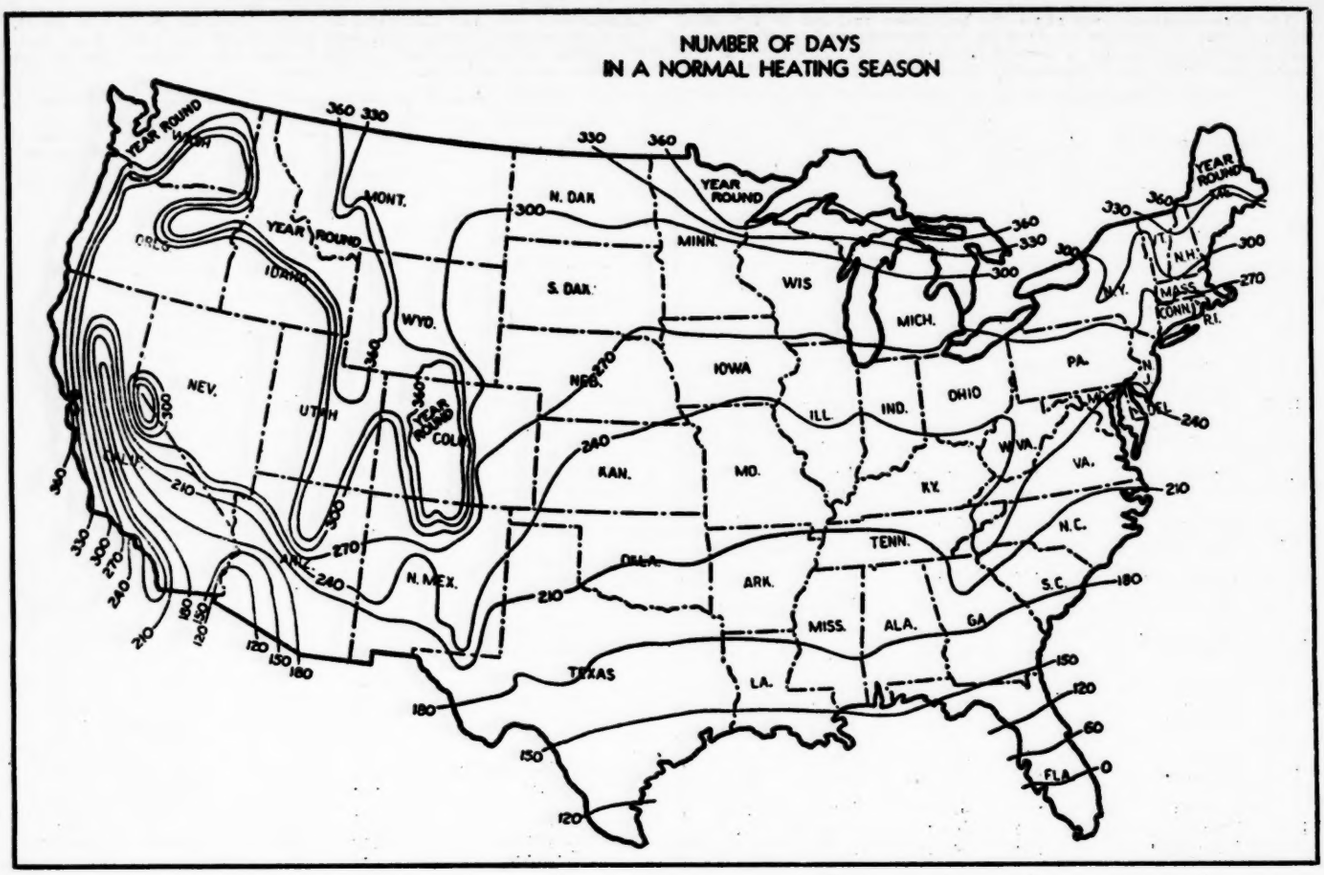
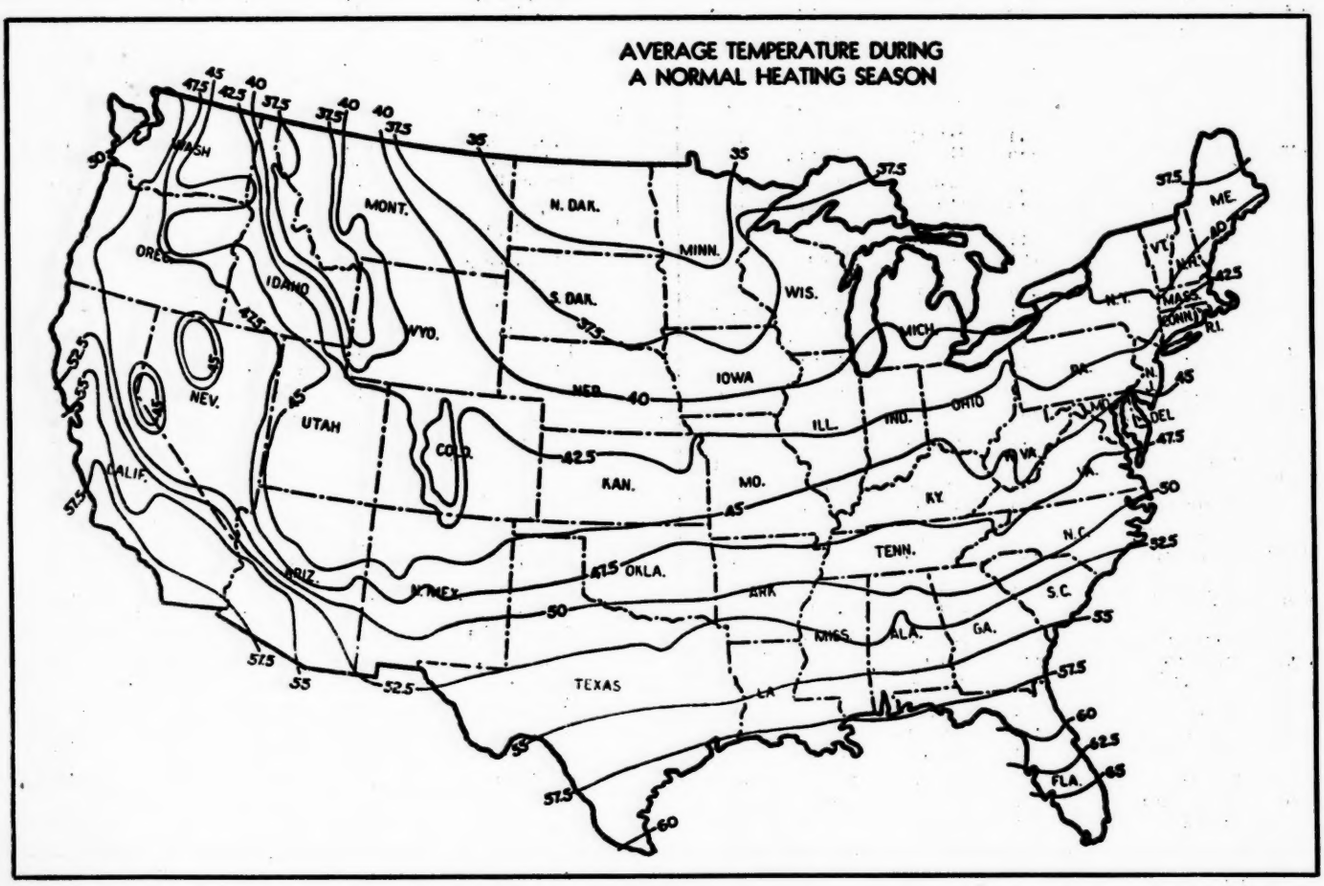
WEATHER DATA FOR NORMAL HEATING SEASON





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CHECK-LIST FOR CONSERVATION OF FUEL

PART I.—PHYSICAL FEATURES OF BUILDINGS

Check List for Exterior of Building Structure

Location	Building Name.....Checked by..... Location..... Date.....

		Side E.	W.	N.	S.
Exterior walls	Need insulation	..	..	..	..
	Have open cracks	..	..	..	..
	Unneeded openings should be closed	..	..	..	..
	Fan opening needs louvers	..	..	..	..
Exterior doorways	Unneeded	..	..	..	..
	Frames need caulking	..	..	..	..
	Doors rattle	..	..	..	..
	Weatherstripping needed	..	..	..	..
	Weatherstripping needs repairs	..	..	..	..
	Door check needed	..	..	..	..
	Door check needs repairs	..	..	..	..
	Storm door needed	..	..	..	..
	Storm door needs repairs	..	..	..	..
	Revolving door could be used	..	..	..	..
	Revolving door needs repairs	..	..	..	..
Loading platform	Outer door needed	..	..	..	..
	Door needs repairs	..	..	..	..
	Rear partition needed	..	..	..	..
	Rear partition needs repairs	..	..	..	..
	Swinging partition door needed	..	..	..	..
Roof	Insulation needed	..	..	..	..
	Ceiling needed	..	..	..	..
	Has open cracks	..	..	..	..
	Unneeded openings	..	..	..	..
	Fan opening needs louvers	..	..	..	..
Skylight	Glass needed	..	..	..	..
	Lower sash needed	..	..	..	..
Penthouse	Insulation needed	..	..	..	..
	Has open cracks	..	..	..	..
	Openings unneeded	..	..	..	..
	Frames need caulking	..	..	..	..
	Doors rattle	..	..	..	..
	Door checks needed	..	..	..	..
	Door checks need repairs	..	..	..	..
	Windows rattle	..	..	..	..
	Weatherstripping needed	..	..	..	..
	Weatherstripping needs repair	..	..	..	..
	Door locks needed	..	..	..	..
	Door locks need repairs	..	..	..	..
	Window locks needed	..	..	..	..
	Window locks need repairs	..	..	..	..
	Glass needed	..	..	..	..
	Putty needed	..	..	..	..

Check List for Interior of Building Structure

Location	Building Name.....Checked by..... Location..... Date.....

		Windows 1	2	3
Windows	Window is unneeded	..	..	..
	Frame needs caulking	..	..	..
	Sash is loose	..	..	..
	Weatherstripping needed	..	..	..
	Weatherstripping needs repair	..	..	..
	Lock needed	..	..	..
	Lock needs repair	..	..	..
	Glass needed	..	..	..
	Putty needed	..	..	..
	Storm sash needed	..	..	..
	Storm sash needs repairs	..	..	..
	Sash cord or pulleys needed	..	..	..
	Weights should be changed	..	..	..
	Shade missing	..	..	..
	Ventilating fan in place	..	..	..
Cracks	Plastering needed	..	..	..
Ceiling	Cracks	..	..	..
	Plastering needed	..	..	..
	Insulation needed (top floor)	..	..	..
Partitions	Door needed	..	..	..
	Door needs lock	..	..	..
	Lock needs repairs	..	..	..
	Transom unneeded	..	..	..
	Transom needs glass	..	..	..
	Transom lock needs repairs	..	..	..
Floors	Openings not needed	..	..	..
	Openings required need covers	..	..	..
Elevator shafts	Solid walls and doors needed	..	..	..
	Walls and doors need repairs	..	..	..
Stair wells	Need solid walls and doors	..	..	..
	Walls and doors need repairs	..	..	..
Basement	(Check in above)	..	..	..

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CHECK-LIST FOR CONSERVATION OF FUEL

PART I.—PHYSICAL FEATURES OF BUILDINGS

Building Improvements to Save Heat

Walls	Add insulation Close openings or cracks Install movable louvers on fan outlets and other useful openings Shut off "dead air" space openings to basement and roof space
Windows and transoms	Replace those unneeded with wall Replace missing, broken or cracked lights of glass Install storm sash Caulk frames Set sash strips to prevent rattle Weatherstrip Caulk sash when not opened Install locks if missing Install new cords if broken Replace window weights if not of proper size Install shades Remove window ventilating fan
Exterior doors	Replace any unneeded door with wall Weatherstrip Caulk frame Reinstall lock-keeper to stop rattle Install storm doors—with vestibule, if possible Install revolving doors Install door checks
Loading platforms	Install partition with double swinging door to main part of building Install exterior door if space permits
Roofs	Add insulation Close openings or cracks Install louvers
Penthouses	Improvements indicated above under walls, windows, doors and roofs
Skylights	Replace those unneeded with roof Install second frame below the first
Interior	Close off elevator shafts and stair wells Install partitions Install doors in existing partitions Close up floor openings Close open fireplaces

Check List for Evening Inspection

File data	Checked by ..... Date.....
Windows	Close storm sash ..... Close shutter* ..... Close ventilator louvers ..... Remove ventilator* ..... Shut off ventilator motor ..... Close window ..... Lock window ..... Pull shade* ..... Note difficulties .....
Doors	Close storm door tight ..... Lock storm door* ..... Close exterior door tight ..... Lock door* ..... Close transom ..... Set revolving door at 45° ..... Close penthouse door tight ..... Close stair-well doors tight ..... Close elevator partition doors tight ..... Close partition doors and transoms*..... Note difficulties .....
Wall, floor and roof openings (Incl. Penthouse)	Shut down fan ..... Close louvers or opening ..... Close roof trap-door tight ..... Close floor openings ..... Note difficulties .....
Radiators	Open valve if under control ..... Shut valve in unoccupied rooms* ..... Note difficulties: Valve ..... Air valve ..... Trap ..... Steam inlet ..... Condensate outlet ..... *If feasible and permissible.

Operating Economy Check List

Methods recommended	Prevent the entrance of cold air through: storm sash; windows; doors; ventilating fan openings; transoms; window ventilators; trap doors; wall and roof openings Clean windows on warm days, during non-business hours and with doors from room closed Decrease transmission losses by pulling shades down and keeping shutters closed Keep daily records of fuel use, degree-days, wind, rain and difficulties Make adjustments when possible during non-business hours
Personnel	Instruct and arouse enthusiasm in building employees When in doubt secure advice from: Local steam utility, heating engineer, control contractor, or heating contractor of ability

These lists are from "Saving Fuel in Heating," by John F. Collins, Jr., Secretary, National District Heating Association, published in Heating and Ventilating, June, 1942. For other check lists see: Heating and servicing, reference data sheets 143, 144, 145, 146; air conditioning drawings, 153-154; air conditioning servicing, 147, 148, 149, 150, 151, 152; air conditioning surveys, 181-182. Sheets 259-260 will present check lists for steam heating systems.

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CHECK LIST FOR CONSERVATION OF FUEL—2

CHECK LIST FOR STEAM HEATING SYSTEM —BASEMENT

LOCATION	Building Name..... Checked by..... Location ..... Date .....
STEAM LINES	Unneeded but connected ..... Uninsulated ..... Flanges uninsulated ..... Fittings uninsulated ..... Too small ..... Improperly sloped ..... Sag in pipes ..... Pocketed ..... Clogged ..... Broken ..... Leaking ..... Special service needed ..... Shut-off valves not accessible ..... Shut-off valve broken ..... Shut-off valve clogged ..... Shut-off valve leaking ..... Relief valves needed .....
RETURN LINES	Uninsulated ..... Too small ..... Improperly sloped ..... Clogged ..... Broken ..... Leaking .....
TRAPS	Too small ..... Faulty ..... Cooling leg too short .....
AIR VENTS	Too small ..... Faulty ..... Automatic regulation faulty .....
RADIATION	Needed .....
CONTROL EQUIPMENT	Motor faulty ..... Wiring faulty ..... Tubing faulty ..... Clock faulty ..... Mechanism faulty .....
PUMPING EQUIPMENT	Motor faulty ..... Wiring faulty ..... Pump faulty .....
PRESSURE REGULATOR	Diaphragm faulty ..... No pressure gauge ..... Improperly installed ..... Governor line faulty .....
CHIMNEY	Repairs needed ..... Cleaning needed ..... Too small .....
GRATES	Wrong type ..... Defective ..... Firing methods .....
GENERATING EQUIPMENT	Added heating surface for boiler ..... Boiler leaking ..... Flues need cleaning ..... Boiler needs insulation ..... Stoker needs repairs ..... Burner needs repairs ..... Door and frame settings show leaks ..... Air handling equipment needs repairs ..... Feed-water regulation faulty ..... Water treating equipment needs repairs.... Boiler dirty ..... Safety valves defective ..... Vacuum and condensation pumps faulty...

CHECK LIST FOR EVENING INSPECTION

INSPECTION	Checked by ..... Date .....
WALL, FLOOR AND ROOF OPENINGS (Incl. Penthouse)	Shut down fan ..... Close louvres or opening ..... Close roof trap-door tight ..... Close floor openings ..... Note difficulties .....
RADIATORS	Open valve if under control..... Shut valve in unoccupied rooms*..... Note difficulties: Valve ..... Air valve ..... Trap ..... Steam inlet ..... Condensate outlet ..... *If feasible and permissible.

CHECK LIST FOR OPERATING ECONOMY

Run ventilating fans only when needed and no faster than necessary.
Check and correct meters.
Heat to no higher temperature than necessary.
Turn steam off wherever and whenever not needed; especially in vacant rooms.
Turn steam off at the main or zone valves rather than at the radiators.
Turn valves either entirely off or entirely on.
Check air-fuel proportion.
Carry a low pressure on steam system; a high vacuum on vacuum system.
Carry a protective ash bed on grates.
Promptly move out ash discharged from grate.
Do not heat up the system for a few persons, lend them electric heaters.
Carry on a regular schedule of maintenance.
Study damper control for best operation.
Study methods of heat saving, sources of building heat loss, heating and ventilating system operation, and peculiarities of tenants.
Instruct and arouse enthusiasm in building employes.
Prepare a valve operation schedule for hand control: For use if there is no automatic control, or for use in case of a failure of control to function.
Keep daily records of fuel use, degree-days, wind, rain and difficulties.
When in doubt secure advice from: Local steam utility, heating engineer, control contractor, or heating contractor of ability.

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CHECK LIST FOR CONSERVATION OF FUEL—2

CHECK LIST FOR STEAM HEATING SYSTEM ROOMS AND HALLS

LOCATION

Building Name..... Checked by.....
Location..... Date.....

RADIATORS

	No.1	No.2	No.3
Unneeded	..	..	..
Location bad	..	..	..
Oversized	..	..	..
Undersized	..	..	..
Shield obstructs	..	..	..
Drapes obstruct	..	..	..
Cover obstructs	..	..	..
Water pan obstructs	..	..	..
Metal radiator reflectors	..	..	..
Painted with metallic paint	..	..	..
Space between fins dirty	..	..	..
Obstructed by furniture.	..	..	..
Air valve faulty	..	..	..
Trap faulty	..	..	..
Shut-off valve inaccessible	..	..	..

RADIATORS (Continued)

	No.1	No.2	No.3
Shut-off valve needs packing	..	..	..
Radiator control valve inaccessible	..	..	..
Orifice undersized	..	..	..
Orifice oversized	..	..	..

LINES

Steam connection undersized	..	..	..
Steam connection pocketed	..	..	..
Steam connection broken	..	..	..
Steam connection leaking	..	..	..
Steam connection uninsulated	..	..	..
Return connection undersized	..	..	..
Return connection pocketed	..	..	..
Return connection broken	..	..	..
Return connection leaking	..	..	..
Return connection uninsulated	..	..	..
Unneeded	..	..	..

Bare line in room.....
Thermostat in room.....

RECORDS AND DATA ON PAST OPERATIONS

Name of Building.....
Location of Building.....
Search by .....
Date .....

Building

Type .....
Age .....
Height .....
Ground Floor Dimensions.....
Major Changes .....
.....
.....
Kind of Fuel Used.....
District Heating Service Used.....
Fuel or Service Records furnished by.....

Heating System

Type .....
Age .....
Kind of Temperature Control.....
.....
Major Changes .....
.....
.....
Degree-days in Normal Year .....

Fuel Record

Period Included Between (Days)	Total Fuel or Service Used	Amount Fuel or Service Non-heating	Fuel or Service Space Heating	Unit	1000 Btu per Unit	1000 Btu for Space Heating	D.D. in Period	1000 Btu per D.D.	1000 Btu per Normal Year
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Conditions During Period

Overheating
General..... Local..... When..... Where ..... Est. Temp..... Cause.....

Underheating
General..... Local..... When..... Where ..... Est. Temp..... Cause.....

Percentage of building occupied .....Percentage heated .....
Was there any other considerable source of heat?.....
Describe .....

Occupancy Hours
Weekdays..... to..... Saturdays..... to Sundays..... to..... Holidays..... to.....
Temperatures during occupancy.....During non-occupancy .....
Odd hour occupants .....
System difficulties such as leaks.....
.....
Tenants opening windows.....
Other tenant peculiarities.....
Skill, energy and enthusiasm of operators.....

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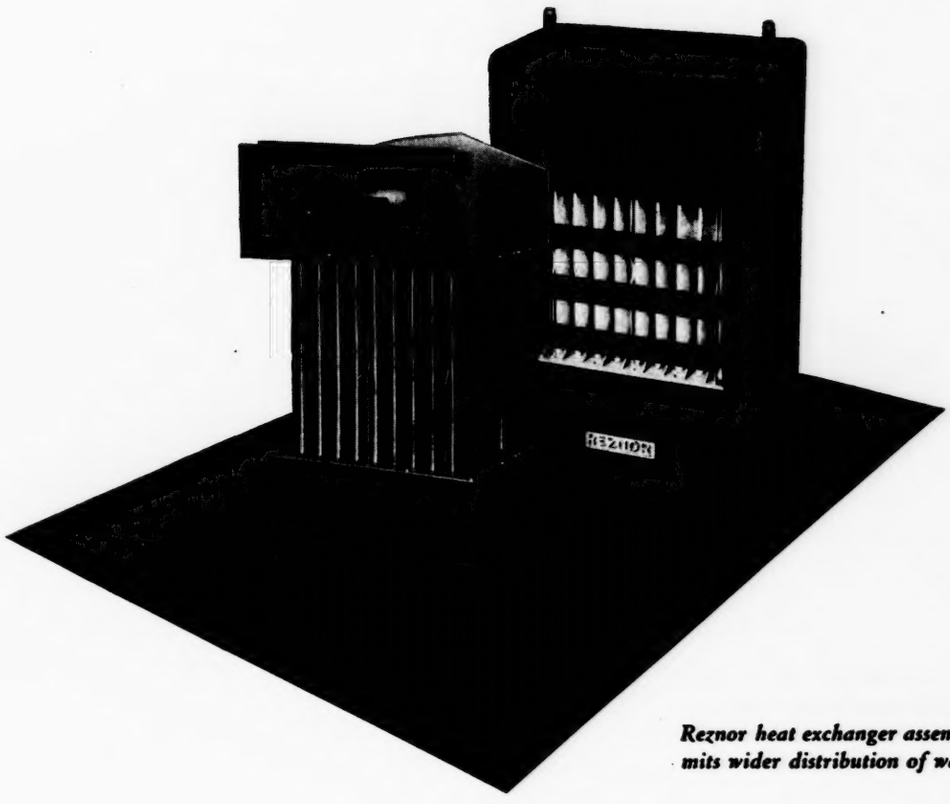
PUTTING MORE B.T.U.'s TO WORK WITH

REZNOR Unit Heaters



Reznor heat exchanger assembly permits wider distribution of warm air.

● Combustion liberates a certain number of B. T. U.'s, but efficiency of any heating unit is measured by the quantity of B. T. U.'s actually delivered as heat.

The Reznor Unit Heater delivers a maximum volume because the heat exchanger section is designed to permit the air to move quickly and efficiently over the heat exchanger tubes. There are no fins or projections to hold back the steady flow of hard-working B. T. U.'s. The compact, self-contained Reznor Heater is easily installed . . . can be relocated without difficulty.

Printed data available upon request. Write today.

REZNOR MANUFACTURING CO., 309 James St., Mercer, Pa.

MODERN GAS HEATING THE REZNOR WAY
DOMESTIC
COMMERCIAL
INDUSTRIAL
REZNOR

"GAS HEATERS EXCLUSIVELY SINCE 1888"

HERMAN NELSON PRODUCTS

in peace and at war

HERMAN NELSON products which were used to heat and ventilate all types of public, commercial and industrial buildings in times of peace are now at war. Since our country started preparations for this war, Herman Nelson Products have been installed in all types of army, navy and war industry projects. They have produced the excellent results and have given the reliable service that they always assured in peace time installations.

In addition, Herman Nelson has been developing and producing special heating and ventilating equipment for the solution of difficult logistic problems. This equipment will find new application when available for civilian use.

When victory has been achieved, architects, engineers and contractors can continue to look to Herman Nelson for progressively designed and well constructed heating and ventilating products.

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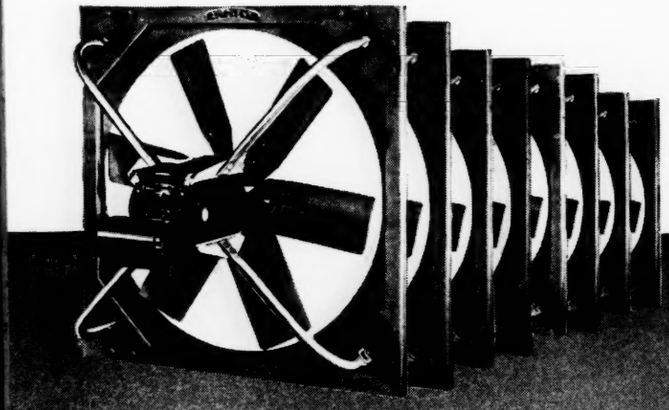
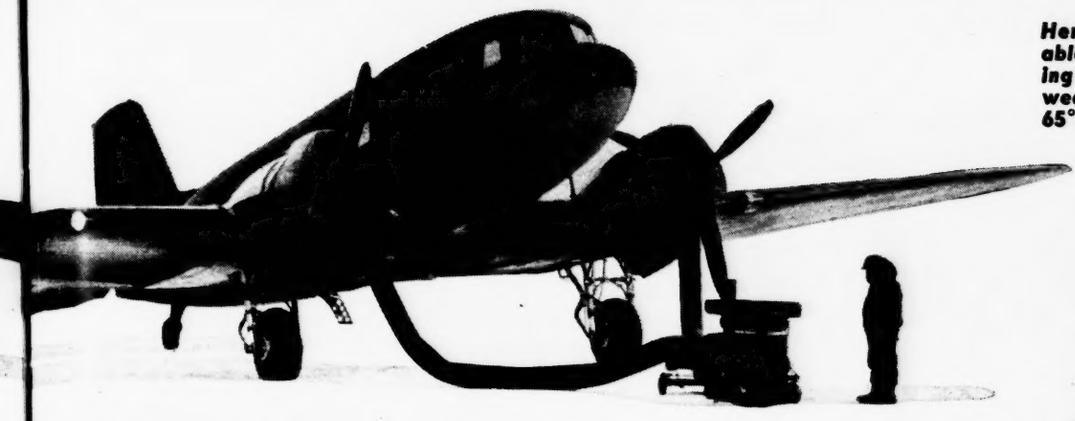
THE HERMAN NELSON CORPORATION

MANUFACTURERS OF QUALITY HEATING, VENTILATING AND AIR CONDITIONING PRODUCTS

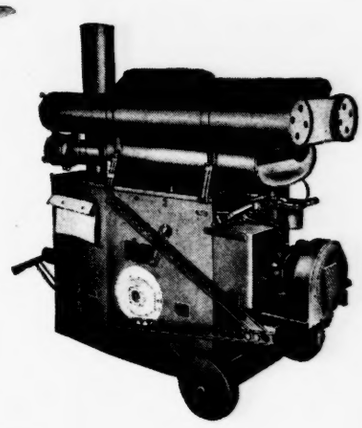
MOLINE, ILLINOIS

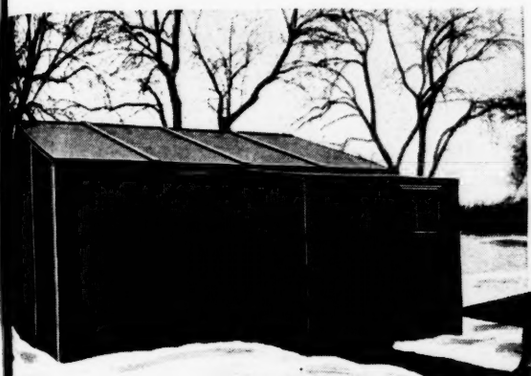


Herman Nelson Autovent Propeller Fans were used to ventilate these buildings constructed in Washington to house government workers. In peace time these fans are used to provide needed air changes for workers in many types of commercial and industrial buildings.

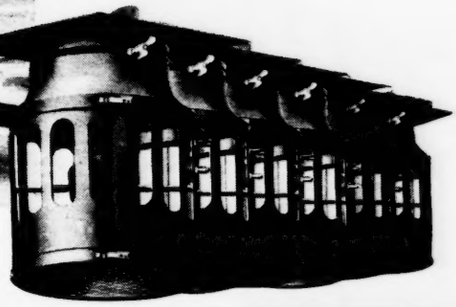


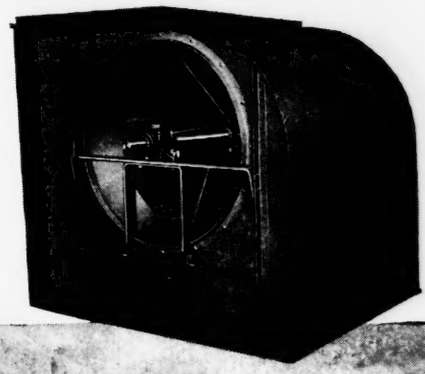
Herman Nelson developed these portable, self-powered heaters for preheating aircraft engines in severe, cold weather with temperatures as low as 65° below zero.



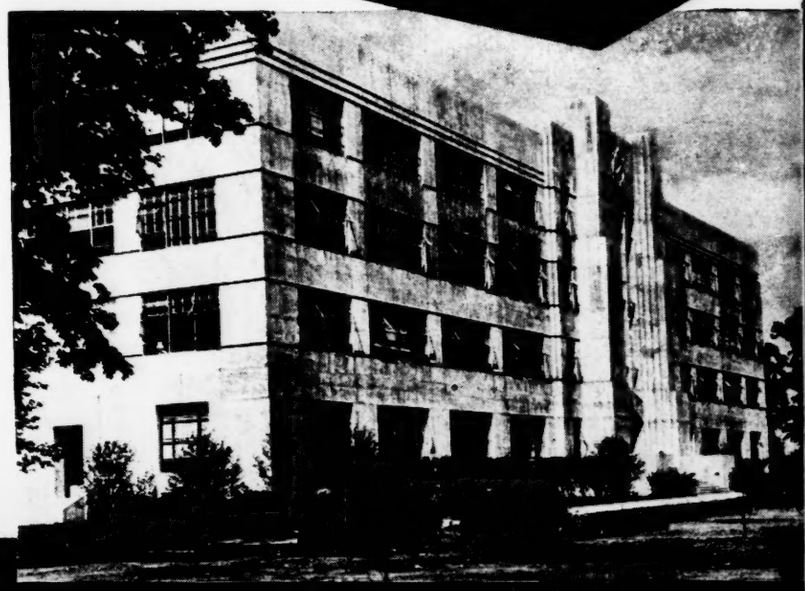


These ventilators were designed by Herman Nelson to overcome stratification in huts used by the armed forces in cold climates.

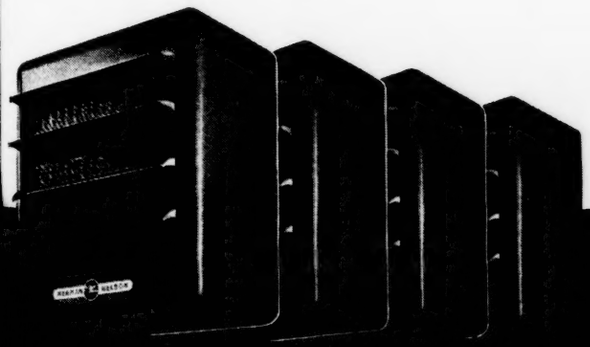


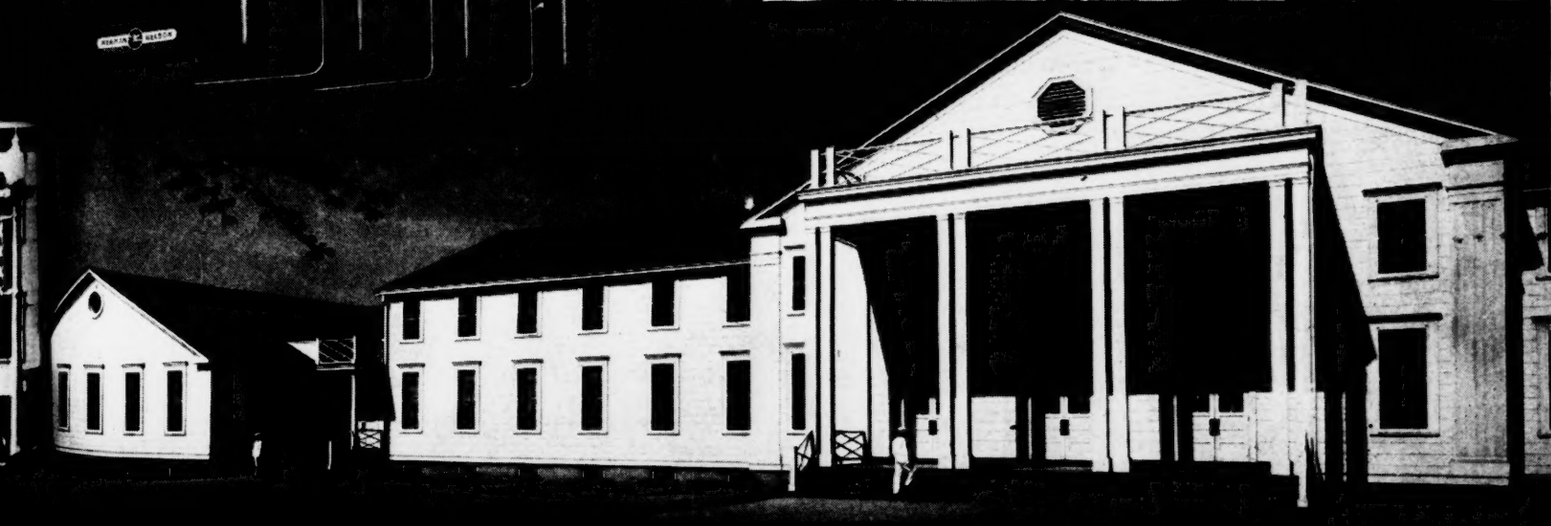


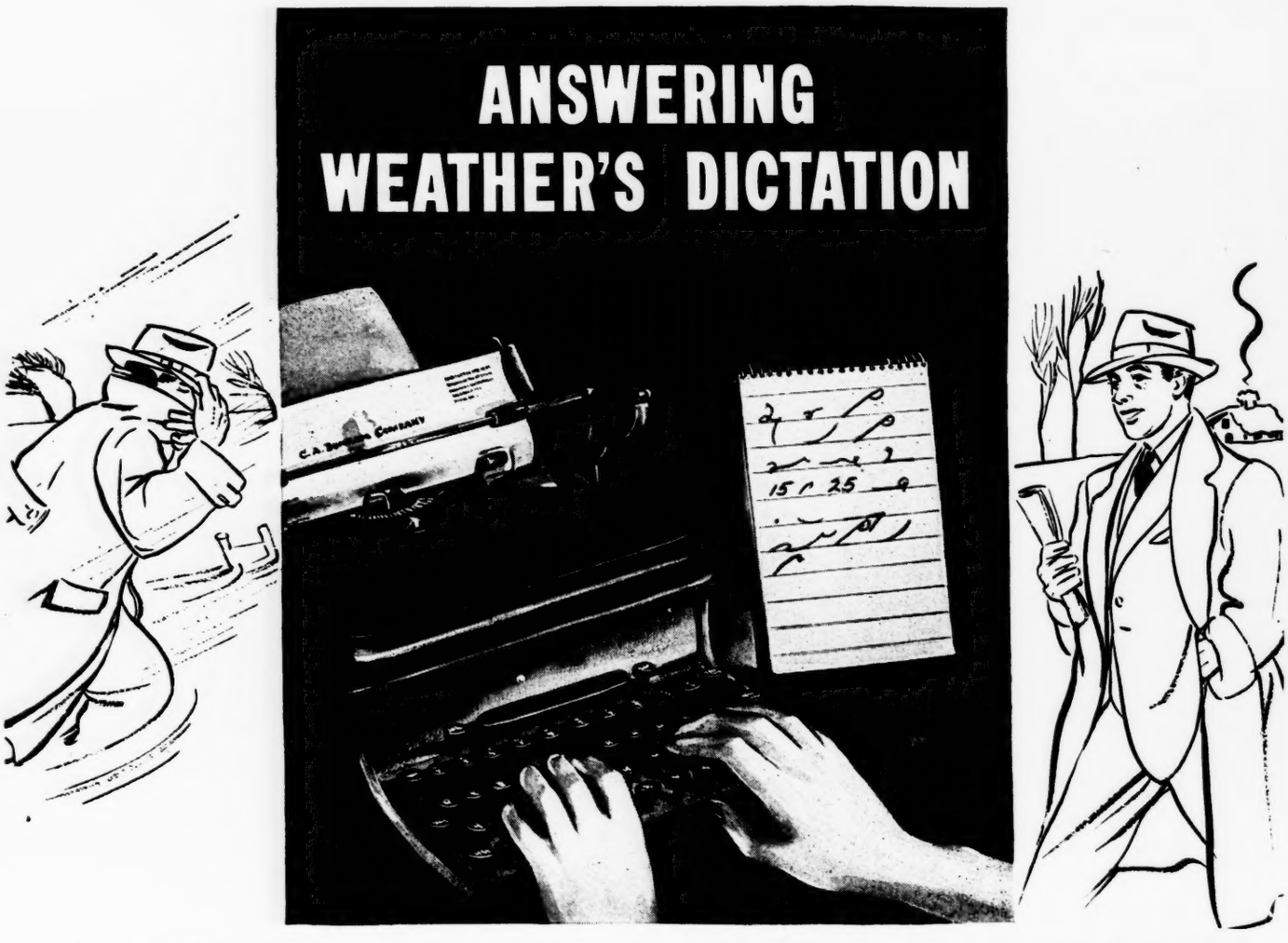
A Herman Nelson Autovent Blower provides ventilation in this Administration Building at one of our government Arsenals. In time of peace these blowers are used not only for ventilation but for many industrial process installations.



This naval station recreation building is heated with Herman Nelson hiJet Unit Heaters. After the war these heaters will provide warmth for recreational space in schools, churches, clubs and similar buildings.







the DUNHAM SYSTEM OF CENTRALIZED CONTROL

Quick control of "building-temperature" saves fuel (solid, liquid or gas). Quick action through a mechanical brain (the Dunham Control Panel) is one outstanding feature of the Dunham System of Centralized Control. A second value is that the temperature of the steam itself and the volume of steam admitted to the system are flexible to meet changeable weather.

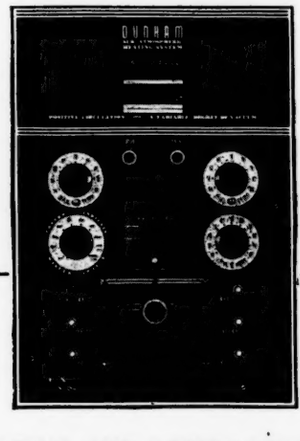
The Human Brain

The brain of the stenographer reads and interprets her shorthand notes, then controls her fingers to strike the correct keys to automatically and instantaneously transpose the pothooks of the notebook into the message which was dictated to her.

Dunham Differential Heating Is Controlled by a Mechanical Brain

The window thermometer (Selector) reads the "notes" of changing wind and weather. It is coordinated with the Heat Balancer (which measures the heat output of the system) and with the room thermometer (which measures room heat requirements). The Panel (Mechanical Brain) is informed electrically the amount of heat to be distributed in the system to exactly balance the heat-input with the heat-loss of the building.

The Mechanical Brain *{the Panel}* checks steam distribution 180 times every hour—3 times a minute—and automatically and promptly controls both the volume and the temperature of the steam admitted to the system. It solves the time-lag problem.



Dunham cuts Fuel costs... Buy War Bonds with the money saved

C. A. DUNHAM COMPANY
450 E. OHIO ST. - CHICAGO (11)
TORONTO, CAN. LONDON, ENG.

U. S. BULLETIN ★ DECEMBER

WINNING THE WAR COMES FIRST!

Men and materials have gone to war. U. S. Radiator and Pacific Steel Boiler are today helping in the production of vital war material. Until this war is won, that is our foremost job.

Serious delays in production schedules, and uncertainties of delivery dates on even the most essential civilian equipment, are understandable under present abnormal conditions. But we should like to go on record that we are bending every effort to give you the best service possible consistent with the primary demands of our country.

Please feel free to write us regarding your problems. Let us work with you now and plan with you for the future when normal service can be resumed.

U. S. RADIATOR IN THE WAR

Magnesium Castings for U. S. war planes are in production in one unit of U. S. Radiator Corporation. Use of light metal alloys is one of the most important developments in the air war today.

Prefabricated Ship Hull Sections for U. S. Maritime Cargo Vessels are being built by Pacific Steel Boiler Division of U. S. Radiator. This Division is also making gun mounts, foundations and platforms.

US RADIANT WARMTH

Member The Institute of Boiler and Radiator Manufacturers

UNITED STATES RADIATOR CORPORATION

AND

PACIFIC STEEL BOILER DIVISION

Detroit, Michigan · Branches and Sales Offices in Principal Cities

Manufacturing Plants At:

Bristol, Pa. · Detroit, Mich. · Dunkirk, N. Y. · Edwardsville, Ill. · Geneva, N. Y. · Waukegan, Ill. · W. Newton, Pa.

Fresh food on the high seas during long, heavy-action periods away from port is the result of compact, efficient refrigeration.

Self-Contained
¼ h.p. Refrigerating Unit

Cool, clean air protects the life of the wounded in Army hospitals. Special aircraft refrigerators safeguard serums and plasma.

Aluminum
Aircraft Refrigerator

Peak welding efficiency is made possible by cooling of welding tips with water or brine held at the right temperature.

Spot Welder
Tip Cooling Unit

Tool life is increased and rejections are fewer when cutting oils used in high-speed machining are properly cooled.

Refrigerating Unit

The health of our armed forces is protected by dependable refrigeration in cantonments, huts, barracks, and on ships.

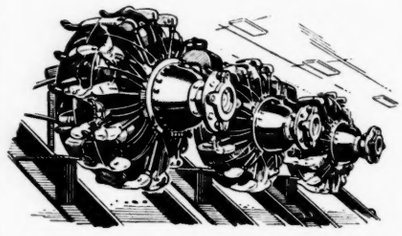
14 Cylinder
Refrigerating Compressor

Super accuracy in gauge rooms is possible when the air is clean, dehumidified, and maintained at a constant temperature.

3 h.p. "Packaged"
Air Conditioner

Protection in the tropics against the ravages of humid atmosphere and vermin is necessary to preserve food and equipment.

Portable Panel
Refrigeration Unit



Identical performance of aircraft engines is assured by operation tests with carburetor air kept at the same temperature.

14 Cylinder
Air Conditioning Compressor

Clean, dry atmosphere is vital for machining sensitive metal surfaces where a spot of rust would ruin high-precision products.

5 h.p. "Packaged"
Air Conditioner

★ CHRYSLER AIRTEMP AT WAR ★

From tiny, fractional horsepower to big 75 horsepower units, Chrysler Airtemp Radial Compressors are performing a major war job on both the production and battle fronts.

The science of air control is built around the compressor. Chrysler Airtemp's *exclusive* Variable Capacity Radial Compressor provides a new efficiency and accuracy in indoor climate regulation. The radial cylinders cut in or out automatically, one at a time, to meet varying load requirements. This flexibility eliminates the peaks and valleys resulting from abrupt starting and stopping of ordinary compressors . . . holds temperature and humidity at a constant level.

Years spent in building delicate mechanisms, have developed high-precision, versatile skills at Airtemp, now devoted to war production. Backed by Chrysler Corporation research and engineering, when peace comes, these skills will again create heating, cooling and refrigeration units for homes and commercial use that will set new, high standards of efficiency and performance.

The lessons learned during peace in free competitive enterprise—freedom of the individual to produce and compete—today bring strength to a nation at war.

War Products of Chrysler Corporation

Tanks • Tank Engines • Navy Anti-Aircraft Guns • Army Anti-Aircraft Guns • Bomber Fuselage Sections • Bomber Wings • Bomb Racks • Bomb Shackles • Fighter Landing Gears • Aluminum Alloy Forgings • Aluminum Alloy Castings • High-Powered Aircraft Engines • Cycleweld Cement • Wide Variety of Ammunition • Anti-Tank Vehicles • Command Reconnaissance Cars • Troop and Cargo Motor Transports • Ambulances • Weapons Carriers • Gyro-Compasses • Navy Pontoons • Marine Tractors • Harbor Tugs • Marine and Industrial Engines • Smoke Screen Generators • Air Raid Sirens and Fire Fighting Equipment • Powdered Metal Parts • Cantonment Furnaces • Tent Heaters • Refrigeration Compressors • Field Kitchens • and Other Important War Equipment

Tune in Major Bowes every Thursday, C B S, 9 P. M., E. W. T.

Chrysler Corporation

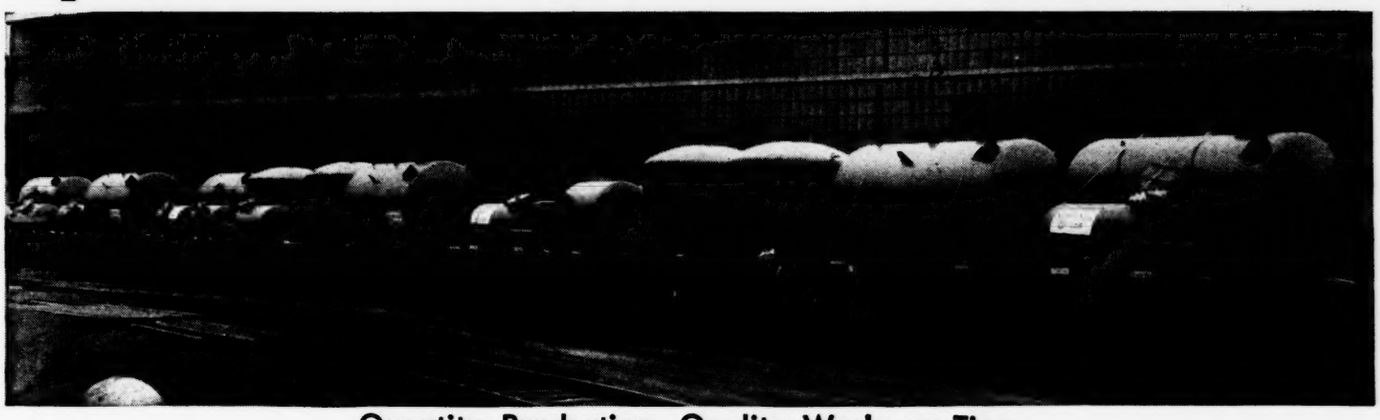
PLYMOUTH • DODGE • DE SOTO • CHRYSLER • AIRTEMP • AMPLEX

BACK THE ATTACK—BUY WAR BONDS

KEWANEE

TYPICAL FLATCAR LOADINGS

Special Tanks for the Synthetic Rubber 'Plantations'



Quantity Production; Quality Work; on Time;
all as demanded in the Emergency Rubber Program

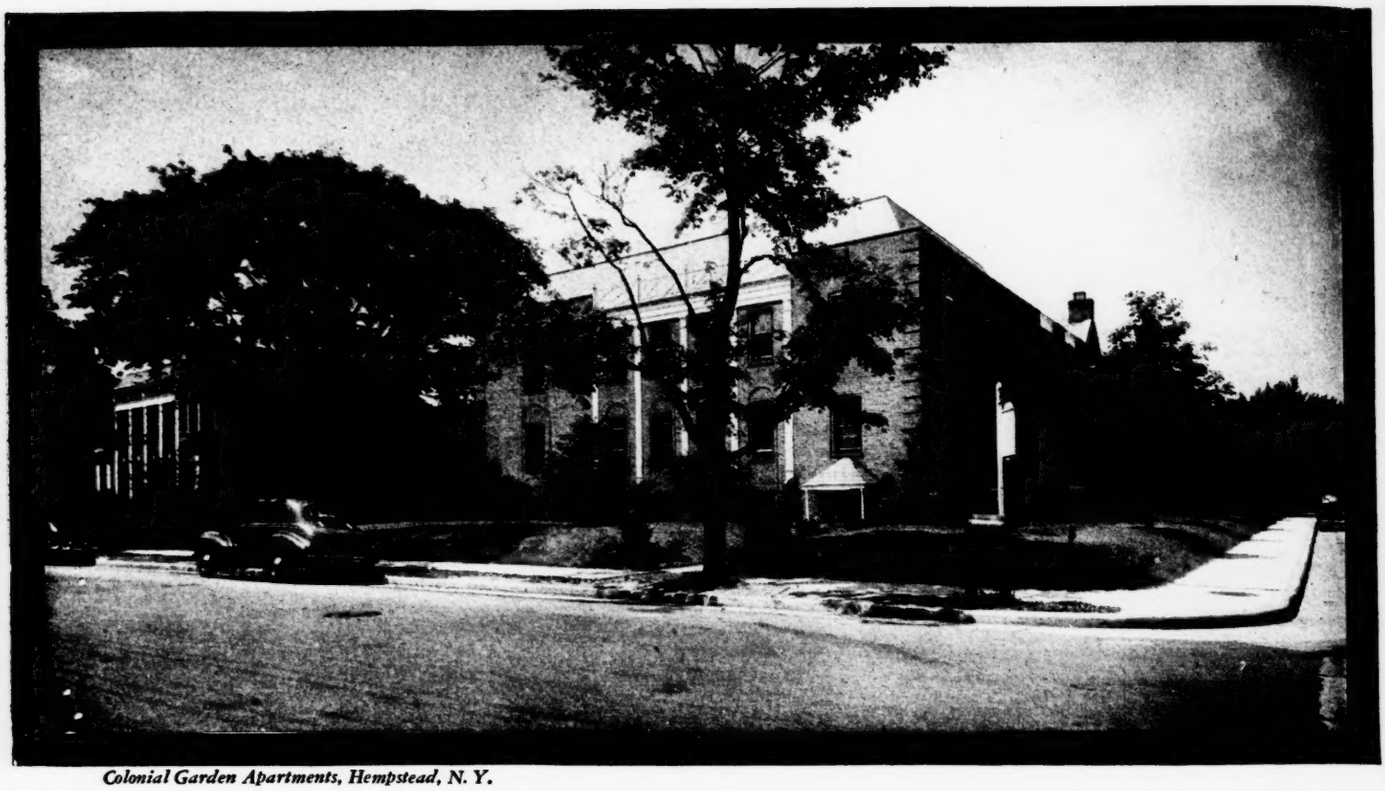
Kewanee is equipped for Riveted Fabrication, large and small. For Hand Welding Low Pressure Boilers & Tanks; or Latest Automatic Welding and Flame Cutting Equipment available on Pressure Vessels and Boilers #1 Weld Stress Relieved.

KEWANEE BOILER CORPORATION
KEWANEE, ILLINOIS
Branches in 60 Cities—Eastern District Office: 40 West 40th Street, New York City 18
Division of AMERICAN Radiator and "Standard" Sanitary Corporation

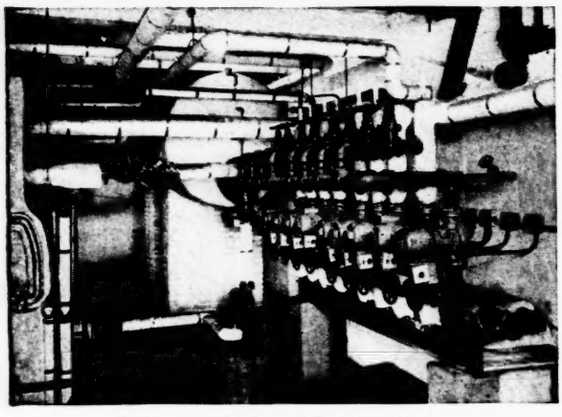
75 YEARS BOILERMAKERS

NINE ZONES OF COMFORT

ALWAYS ENOUGH HEAT...NEVER TOO MUCH...IN THIS GARDEN APARTMENT



Colonial Garden Apartments, Hempstead, N. Y.



Boiler room of Colonial Gardens, showing nine zones controlled by B & G Boosters

To a post-war world demanding new and improved ways of doing old things, the B & G Monoflo System contributes better apartment house heating at lower fuel cost.

The ideal heating system is one in which the heat input can be closely balanced with the heat output . . . *which makes forced hot water the obvious choice!* Water can be circulated through a *long range* of temperatures, thereby permitting close adjustment of the heat delivery to the actual need for heat.

Easy zoning is a further asset—the nine zones in the apartment illustrated above assure greater tenant comfort, and by eliminating over-heating, save materially in fuel. Important, too, is the Monoflo method of piping used in this building, which enables *one* pipe main to do the work of two. Less designing time, easier installation and lower cost all help account for the phenomenal growth of B & G Monoflo Heating.

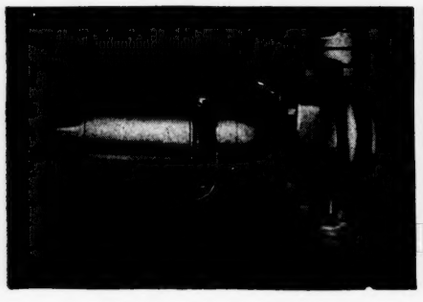
For complete design instructions, send for B & G Handbook.

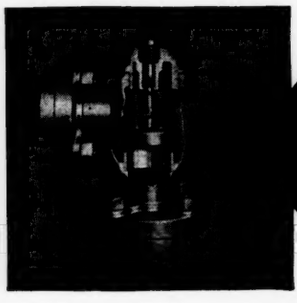
B&G MONOFLO SYSTEM

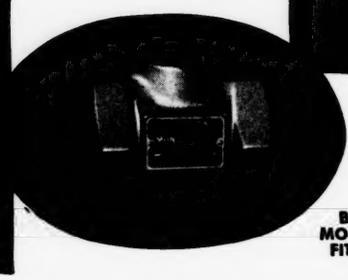
BELL & GOSSETT COMPANY

MORTON GROVE, ILLINOIS (Suburb of Chicago)

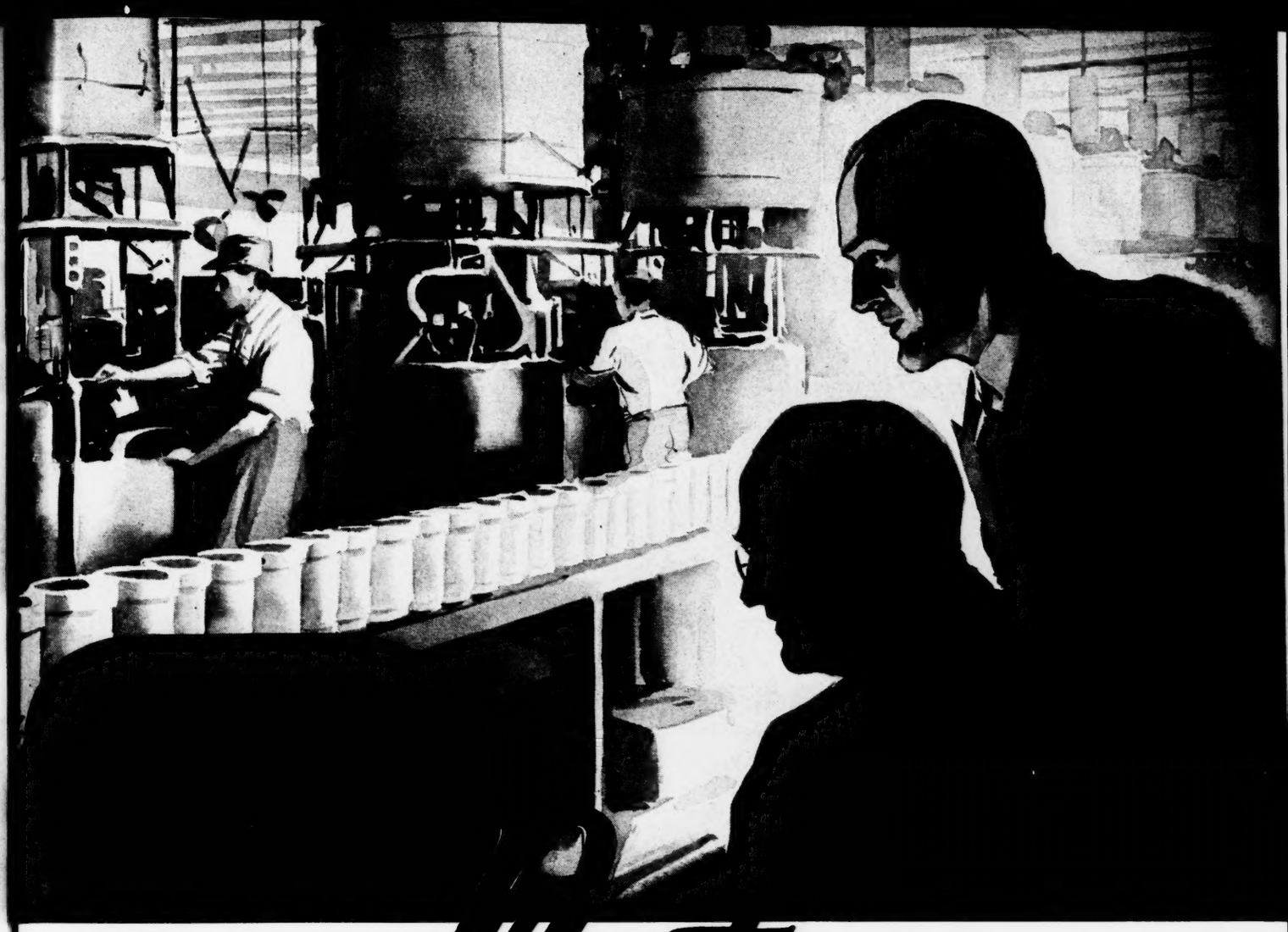
Canadian Licensee: S. A. Armstrong, Ltd., 115 Dupont St., Toronto







B&G MONOFLO FITTING



FOR *Postwar* AIR CONDITIONING

PRECISION manufacturing and processing, as well as employee comfort will be just as important after the war as it is now — probably more so, for competition will be keener. Now is the time to plan for the air conditioning installation you want. This will eliminate possibility of delay and will help you to quickly change back to peacetime production . . . Minneapolis-Honeywell engineers have developed many improvements which will benefit you. They will be glad to work with you, your architects, or your heating engineer on your postwar plans, without cost or obligation . . . Minneapolis-Honeywell Regulator Co., 2715 Fourth Avenue S., Minneapolis 8, Minnesota. Branches in 49 cities.

Buy More War Bonds!

INSTRUMENTS BY **BROWN** FOR INDUSTRY

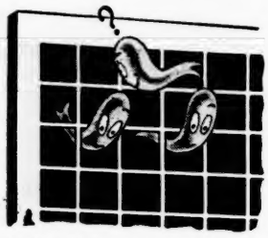
MINNEAPOLIS-HONEYWELL

TEMPERATURE CONTROLS

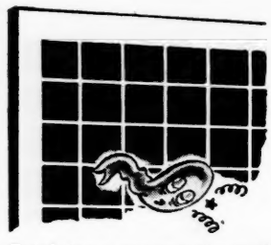
HOW *PRECIPITRON** WORKS

You get 90% CLEANER Air with ELECTRIC Air Cleaning

Uncleaned air contains dirt particles of various sizes.



Mechanical cleaners permit small particles, or about 10% of the dirt, to "escape."

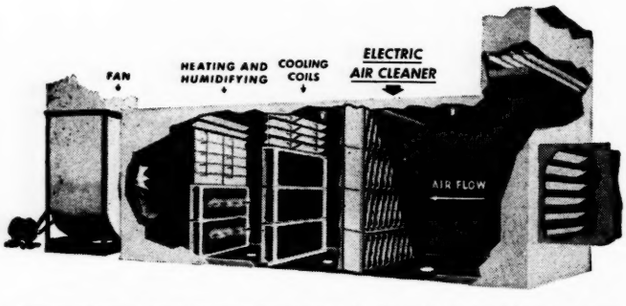


Precipitron removes the *small* particles, too; is 99½% efficient (based on weight tests).

Yes . . . 90% *cleaner* air than is provided by conventional air cleaners. For each ounce of dirt that "escapes" in a mechanical air cleaner, *less than 1/10 of an ounce* gets through the Precipitron. The reason for this is that the Precipitron, operating electrostatically, removes air-borne particles as small as 1/250,000ths of an inch in diameter.

Sealed within the ventilating duct so that all air must pass through it, the Precipitron operates silently, efficiently, with no more moving parts than a storage battery. At the front of the unit (or cell), two fine tungsten wires and three grounded rods create a strong electrostatic field. As each particle of dirt passes through this field, it receives a positive charge of electricity.

These charged particles are then carried by the air stream to *collector plates* located behind the electrostatic field. Here the dirt particles are quickly "grounded" on the oppositely charged plates. And here they stay . . . until the plates are washed down with water and the deposit flushed harmlessly down the drain.



Cross section of Precipitron installation in typical air conditioning duct.

Because Precipitron consistently removes more than 99½% of ALL air-borne dirt (measured by weight), it has given a new meaning to commercial and industrial air cleaning. For full information on Precipitron and its applications . . . for immediate use in vital war production . . . or postwar use in other fields . . . write Westinghouse Electric & Manufacturing Company, Edgewater Park, Cleveland, Ohio.

*Trade-mark registered in U. S. A.

Westinghouse Precipitron

PLANTS IN 25 CITIES ○ OFFICES EVERYWHERE

Tune in on John Charles Thomas, NBC, Sundays, 2:30 p.m., E.W.T.

Electronics at Work

WeldELLS have everything ★

"They're built to give the man on the job a hand"

FROM the way they pile the work on me these days you'd think my job as foreman of the pipe crew is to put in the piping today that the front office won't finish planning till tomorrow!

The front office crowd might consider that laying it on a little thick. But whatever they think, they will have to admit that we have kept up with their wildest demands and done the job right, too.

Of course the main credit for that goes to fellows who do the work. But down to the last man they would be the first to agree that they couldn't have covered as much ground, or covered it as well, if it hadn't been for their old friend, WeldELLS.

WeldELLS and other Taylor Forge Welding Fittings are built to step in and give a hand. You don't have to grope for the proper size because size and weight are marked right there on the fitting. Tangents make them easy to line up. Accurate lathe bevels and lands make welding fast and sound. Precision quarter-marks guide the work.

If you want a fast job — a sound job — an economical job — take a tip from me and use the welding fittings that have *everything!*

★ **WeldELLS alone have all these features:**

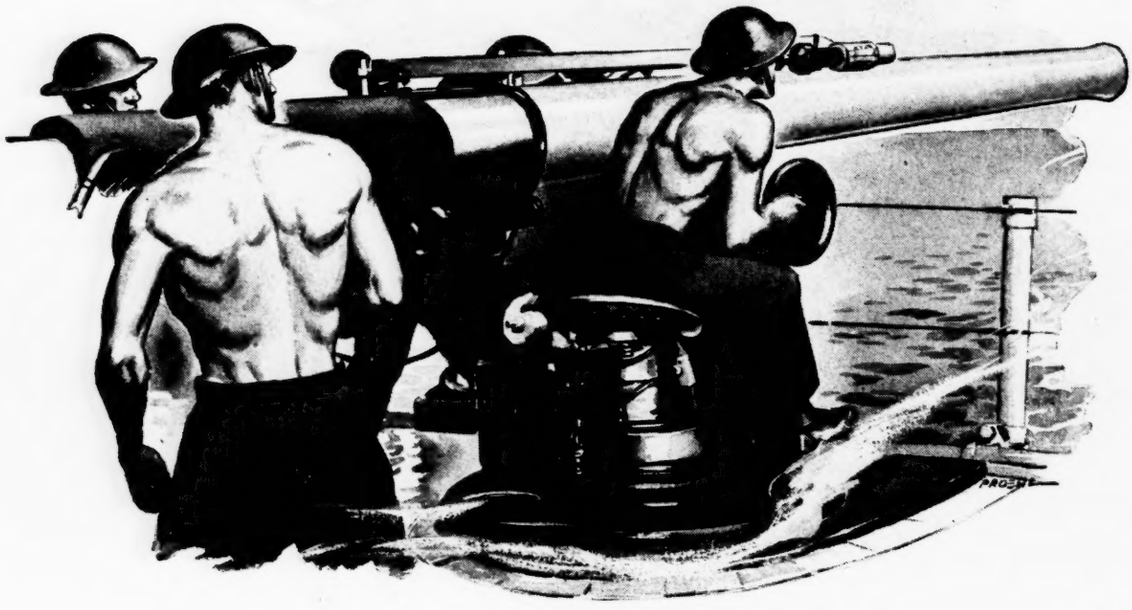
- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

The list of Taylor Forge's contributions to the war effort only begins with WeldELLS. One of many examples is Taylor Corrugated Marine Furnaces, essential to many merchant ships and transports.

* WeldELLS and many other Taylor Forge products are produced in Byers Genuine Wrought Iron.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago, P. O. Box 485
NEW YORK OFFICE: 50 CHURCH ST. • PHILADELPHIA OFFICE: BROAD ST. STATION BUILDING

★ ★ ★ ★ ★ ★ ★ ★



WHAT HAS A SEA BATTLE TO DO WITH YOUR CONTROL REQUIREMENTS?

In a split-second after steel-nerved men at our navy guns get the range, shells go crashing toward the enemy target. The guns have been stung to action by an electric trigger switch!

Instant... unfailing response to the gunner's touch must come from the firing control circuit—a "harness" of electric cables, junction boxes, snap switches, transformer, fuses and solenoid mounted on each gun. The fate of a ship and its crew... perhaps the safety of a convoy... or even the outcome of a battle may hang on the speed and dependability of these electric controls.

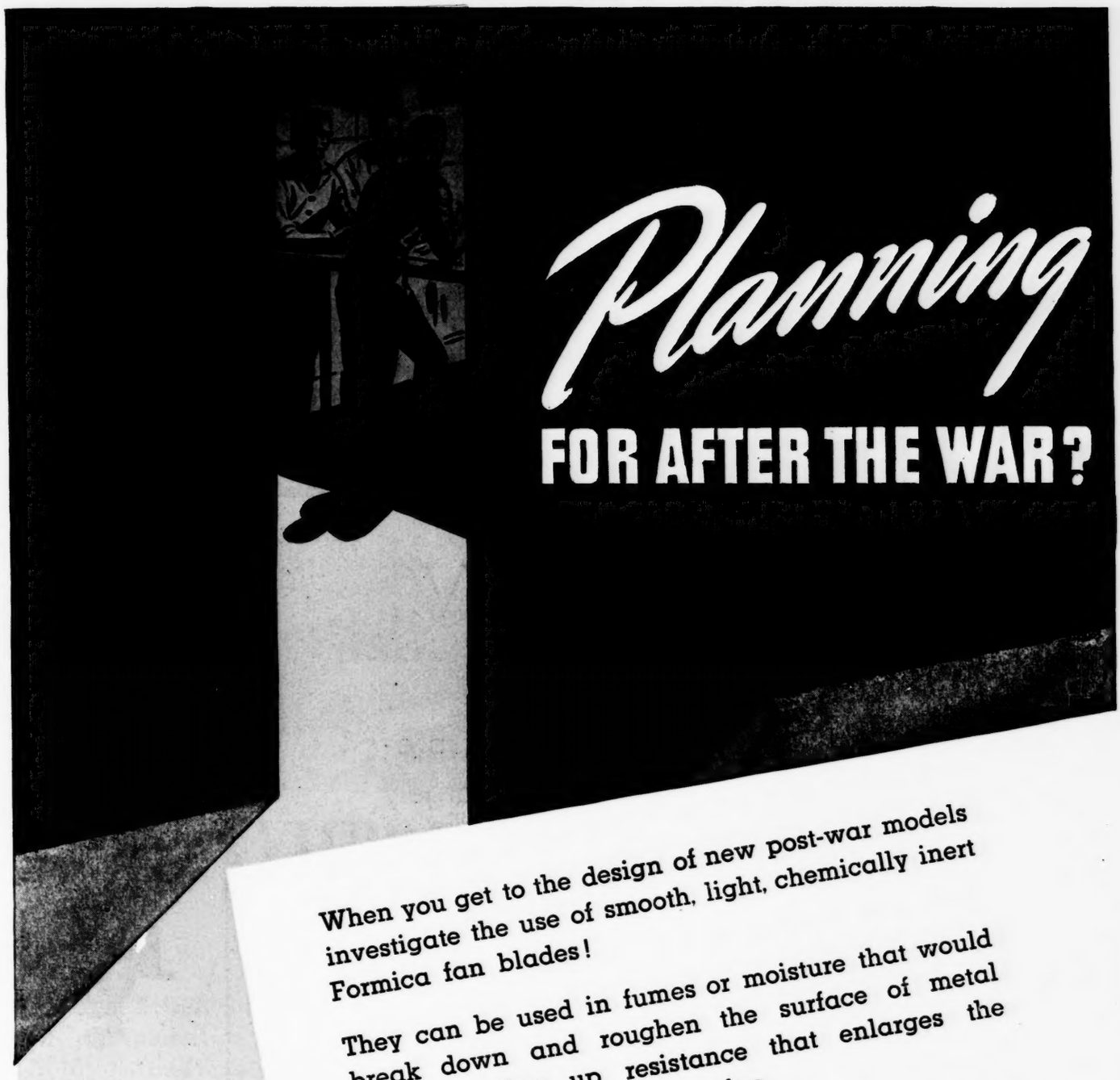
Part of our work for the armed forces is to supply these lighting and firing circuits for the Navy's 3" and 5" guns. Because our skilled workers and critical materials must meet this urgent need, the number of Penn controls available is necessarily limited.

However, we are able to supply automatic heating and refrigeration controls to meet vital commercial and industrial needs. We suggest you ask your jobber—or write us about controls for your requirements. And remember this... *our experience in meeting the exacting requirements of battle-worthy equipment will be reflected in still better Penn controls for post-war heating and ventilating.* That is what a sea battle has to do with your control requirements. *Penn Electric Switch Co., Goshen, Ind.* In Canada: Powerlite Devices, Ltd., Toronto, Ont.

PENN

AUTOMATIC CONTROLS

FOR HEATING, REFRIGERATION, AIR CONDITIONING, ENGINES, PUMPS AND AIR COMPRESSORS



Planning
FOR AFTER THE WAR?

When you get to the design of new post-war models investigate the use of smooth, light, chemically inert Formica fan blades!

They can be used in fumes or moisture that would break down and roughen the surface of metal blades, setting up resistance that enlarges the power requirements of your fan.

But Formica blades, with smooth contours, will remain smooth for years—avoiding replacements, saving power every day they are in use. They are quiet, too.

This is the ideal blade material for any fan made in sufficient quantity to make it economical to provide molds for the blades.

THE FORMICA INSULATION COMPANY
4665 Spring Grove Avenue **Cincinnati 32, Ohio**

Stok-A-Timer
A very dependable stoker control. Easy to adjust for various conditions.

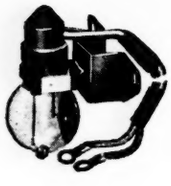
SENSATHERM
Recognized as the most dependable thermostat on the market. It maintains an even room temperature without the use of artificial acceleration.

HBH SENSATHERM
A two-stage thermostat of proven merit. Successfully used on Hi-low burners and with hot water heat having forced circulation.

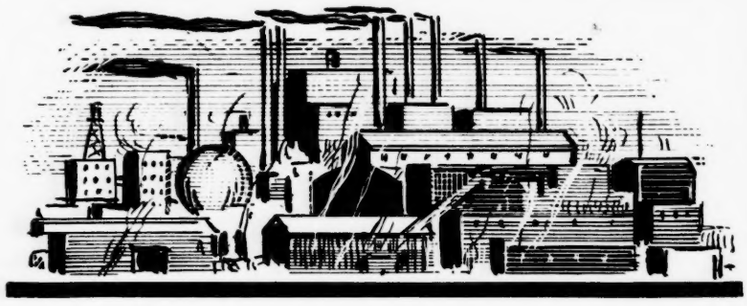
Safety & Ignition Control
Well known to the trade for its all-around dependable service. Guards against flame or ignition failure.

HOT WATER LIMIT
A new and convenient type with outside adjustments. Available also as a combined limit and forced circulation control.

WARM AIR LIMIT
A new small type with outside adjustment. A similar control also available for fan or blower application.



Visaflame
A light actuated safety control system assuring full protection against flame, ignition or power failure. A great improvement in oil burner control performance. Types available for domestic and industrial applications.



NOW

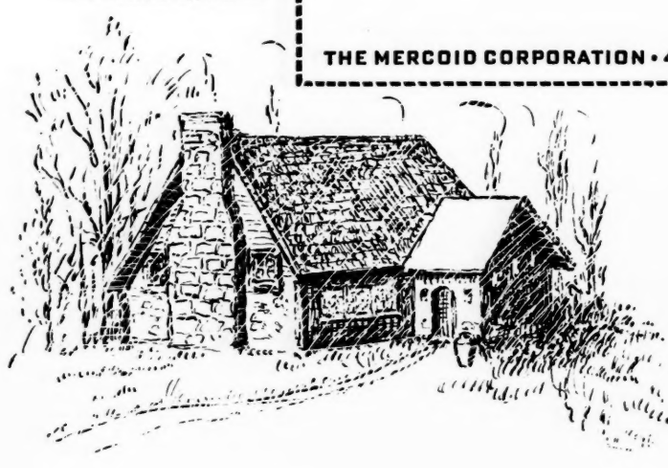
Mercoid Control production is now largely confined to industrial types for American industry engaged in essential war work.

THE MERCOID CORPORATION • 4201 BELMONT AVE. • CHICAGO, ILL.

Pressure Control
This control has a record for its reliable service and long life. The outside double adjustment is a favorite with the trade.

Immersatherm
A summer-winter domestic hot water supply control. Used with steam, vapor and hot water systems, also on many industrial applications.

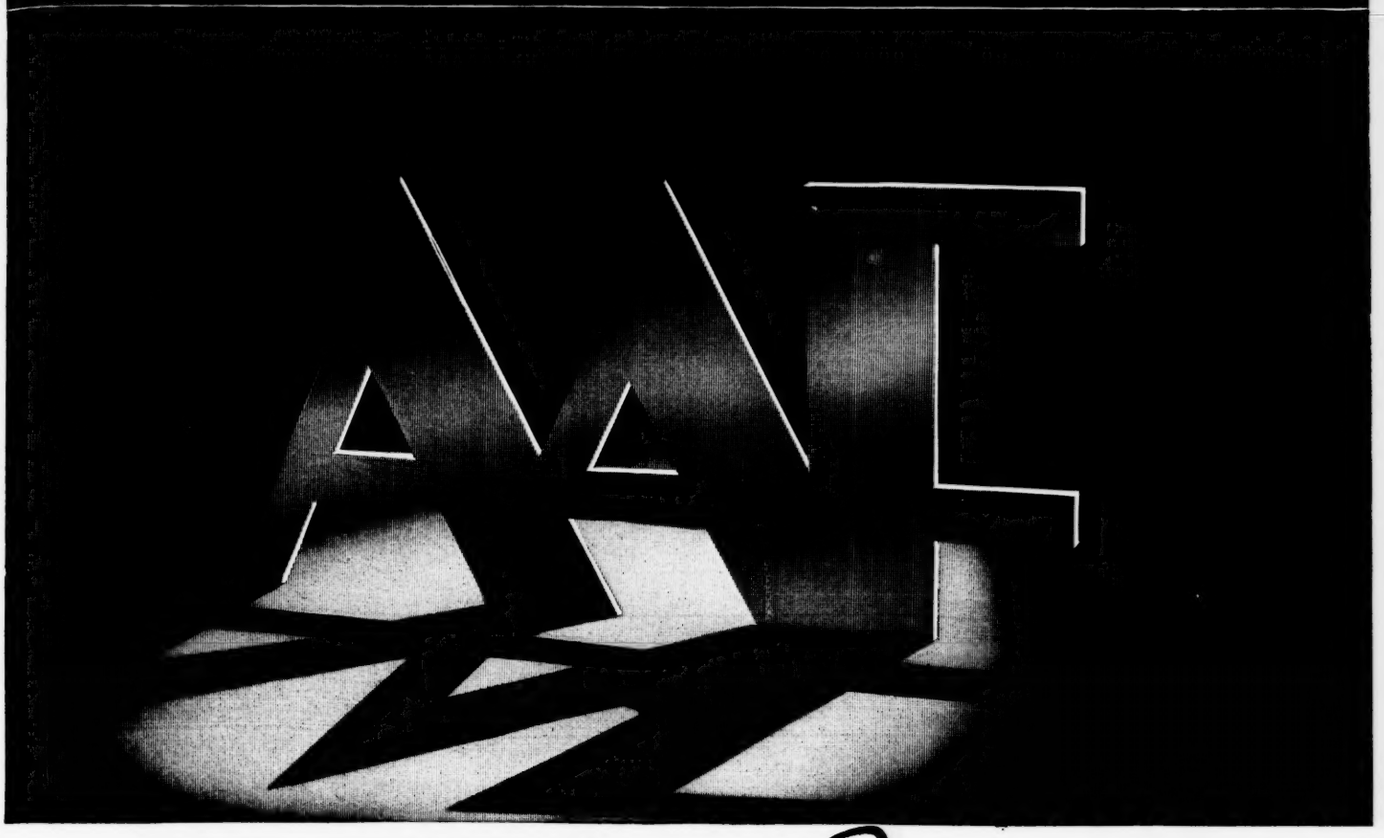
Combined Pressure & Low Water Control
Guards against low water and excess pressure in steam boilers.



WHEN IT'S OVER

—and we again get back to the normal way of life, many more homes will have the opportunity of enjoying automatic heat the Mercoid way of perfect room temperature control with oil heat, coal stokers, etc., on any type of heating plant

AIR FILTRATION AAF DUST CONTROL



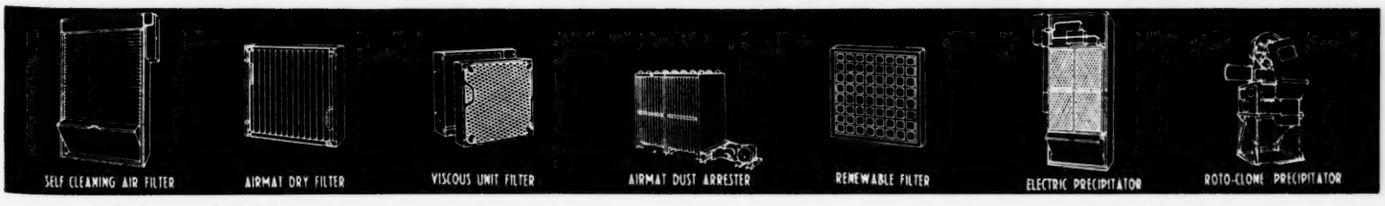
THE SYMBOL of *Clean* AIR

American Air Filter dust control and air filtration equipment is in general use in every field of American manufacture—reducing operating costs, eliminating dust hazards, accelerating production and protecting quality. Many of the phenomenal achievements of precision manufacture developed during the war period have been made possible by AAF dust control. The same is true of the development of many of the synthetic products that have been in the forefront of the news due to diversion of the more strategic materials to direct war use.

Because AAF research and engineering have kept pace with industrial progress and because AAF dust control equipment has so successfully met the air cleaning requirements of each new advancement in manufacturing technique, the AAF trade mark has become the *Symbol of Clean Air.*

● If you have a dust problem, there is an AAF engineer close by who would be glad to discuss it with you without obligation. Send for our latest bulletin, "AAF In Industry."

THE AMERICAN AIR FILTER COMPANY, INC., 294 CENTRAL AVENUE, LOUISVILLE, KY.
INCORPORATED IN CANADA: DARLING BROS., LTD., MONTREAL, P. Q.



Wartime food dehydration flings a challenge at America's air conditioning engineers

During World War I, our country was perfecting methods for dehydration of vegetables. By removing moisture from garden-fresh vegetables, these foodstuffs would be condensed, packaged to save space and weight. It sounded like a wonderful idea. Yet, after war ended, little more was heard about dehydrated foods.

With Pearl Harbor and another war making food a fighting necessity, talk of dehydration again came to the forefront. Hundreds of thousands of tons of dehydrated foods were ordered by the armed forces and lend-lease. Plants plunged into production of this vast supply of concentrated foods.

Food processors have done a remarkable job. But it will be necessary to perfect final-stage drying operations before the industry is satisfied it has complete mastery of the involved process. This is a task which only air conditioning engineers can solve.

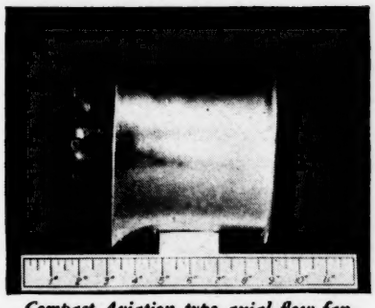
Successful final drying requires extremely low vapor pressure in the finishing bin. This can be accomplished most satisfactorily by the Bryant Dehumidifier, because it pulls a progressively lower moistur content as the product dries, bring ing the air to an almost anhydrou condition at the end of the proces

The success of food dehydratio is largely up to the air conditionin engineer. Gentlemen . . . will *yo* pull on the gloves for the next an feature bout?

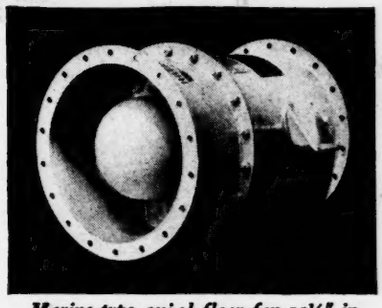
Bryant
DEHUMIDIFIERS
THE BRYANT HEATER COMPANY
17825 St. Clair Ave., Cleveland 10, Ohio

LA-DEL *AXIAL-FLOW* AIR FANS

-a name assuring many advantages for post-war developments in the movement of air

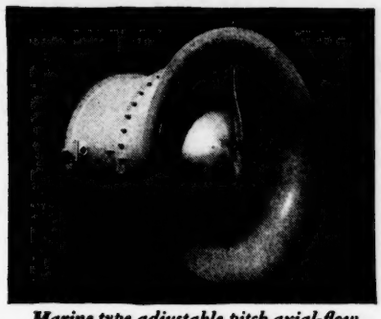


Compact Aviation type axial-flow fan only 6½" in diameter x 6" long delivering 400 CFM at 6" static pressure.



Marine type axial-flow fan 15½" in diameter; delivering 2000 CFM at 3" static pressure.

Marine type explosion proof fan 10½" in diameter delivering 500 CFM at 2½" static pressure.



Marine type adjustable pitch axial-flow fan with flared intake.

All aluminum Aviation type axial-flow fan. 70 lbs. complete with 2½ HP motor; 4300 CFM at 2" static pressure.

11 ft. diameter axial-flow fan with exhaust stack and air shaft hood delivering 500,000 CFM at 6½" static pressure.

HERE are a few of the developed sizes of La-Del Troller Axial-Flow Fans. Wartime conditions have prevented offering La-Del Axial-Flow Fans to industry in general, because of war agencies' demand for compact units of this kind.

A wide variety of models at present are available ranging from ⅛ HP to 1000 HP; from ¼" static pressure to 45" static pressure; from 6" in diameter to 11 feet in diameter; and, from 400 CFM to as much as 600,000 CFM.

Post-war La-Del requirements will probably bring about the development of many additional sizes to meet industry's requirements, since present application of Axial-Flow Fans has firmly established the many desirable design features of this type fan.

Many models are available with either fixed pitch blades or adjustable pitch or controllable pitch, making available fan operating ranges never before realized. Control of operation and air delivery is accordingly more closely regulated with the numerous advantages resulting from this in many applications.

ARMY E NAVY

BUY WAR BONDS TO SPEED VICTORY

LA-DEL CONVEYOR & MANUFACTURING CO.

NEW PHILADELPHIA, OHIO

LA-DEL

★ PIONEERS IN THE DESIGN OF AXIAL-FLOW FANS FOR EFFICIENT AIR CIRCULATION ★

"THIS YEAR, LET'S PAY THE BONUS IN WAR BONDS

. . . and drive even harder on the pay-roll savings plan!"

Make War Bonds the Christmas Order of the Day. Urge your workers to make their personal Christmas gifts in the form of War Bonds—and practice what you preach! Make this a 100% War Bond Christmas—to insure future Yuletides of peace and prosperity.

Make up your own posters to spread the "War Bonds for Christmas" story across your plant. Tell the story again and again on bulletin boards, in your plant magazine, and on pay envelope stuffers.

But don't forget your basic, all-important Pay-Roll Savings Plan. How's it going, these days? Perhaps it needs a bit of stoking-up right this very minute, to hold its full head of steam against the competitive demands of the holiday season.

Well, you're the man to stoke it! You can't expect it to keep running indefinitely on last summer's enthusiasm. See to it that your participation percentages, and your deduction percentages, *both* end up the year at new levels.

Every month, now your Pay-Roll Savings ought to run well ahead of the preceding month. *For so many families that formerly depended on the earnings of a single worker, now enjoy the combined earnings of several.* Such *family* incomes are doubled, trebled, even multiplied many times.

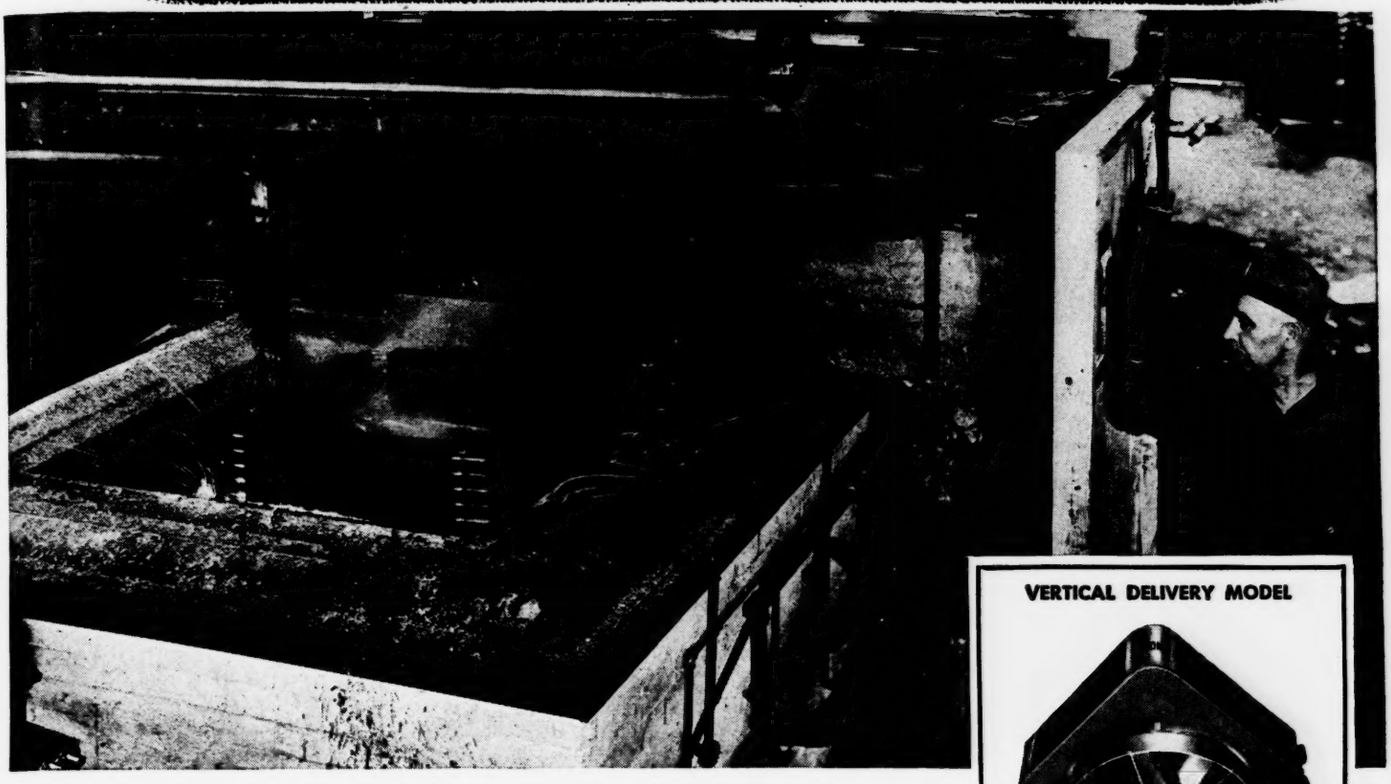
Now's the time to turn as much as possible of these increased earnings into War Bonds—War Bonds for Christmas . . . and War Bonds the whole year 'round!

GIVE THE PRESENT WITH A FUTURE—WAR BONDS!

This space contributed to Victory by HEATING AND VENTILATING

This advertisement prepared under the auspices of the United States Treasury Department and the War Advertising Council

What...Dunking a Unit Heater?



That's right...just like a doughnut in a cup of coffee.

You see, wartime unit heater condensers are made of steel and iron instead of copper. Unless they are adequately protected from atmospheric moisture, they will rust and corrode with resulting reduction in heating capacity and service life.

To prevent this from occurring, the Modine Unit Heater condenser is "dunked"...completely submerged in molten lead alloy before receiving its baked enamel finish.

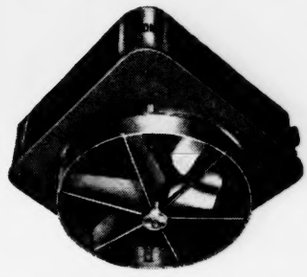
"Dunking" provides a *rust-resistant coating over the entire condenser... and permanently bonds fins to tubes with metal, sealing these important heat transfer contacts from corrosion.*

This built-in protection against rust and corrosion, like Modine's use of *extra heavy ingot iron tubes,* and *Bonderized casings* is your assurance of maximum wartime unit heater durability.

GET CATALOGS 143-A and 143-B

Look in your phone book for Modine representative's name—"Where to Buy It" section.

VERTICAL DELIVERY MODEL



NOW YOU CAN GET

modine

UNIT HEATERS

on an AA-5 priority, or better — or, on a repair order such as MRO.

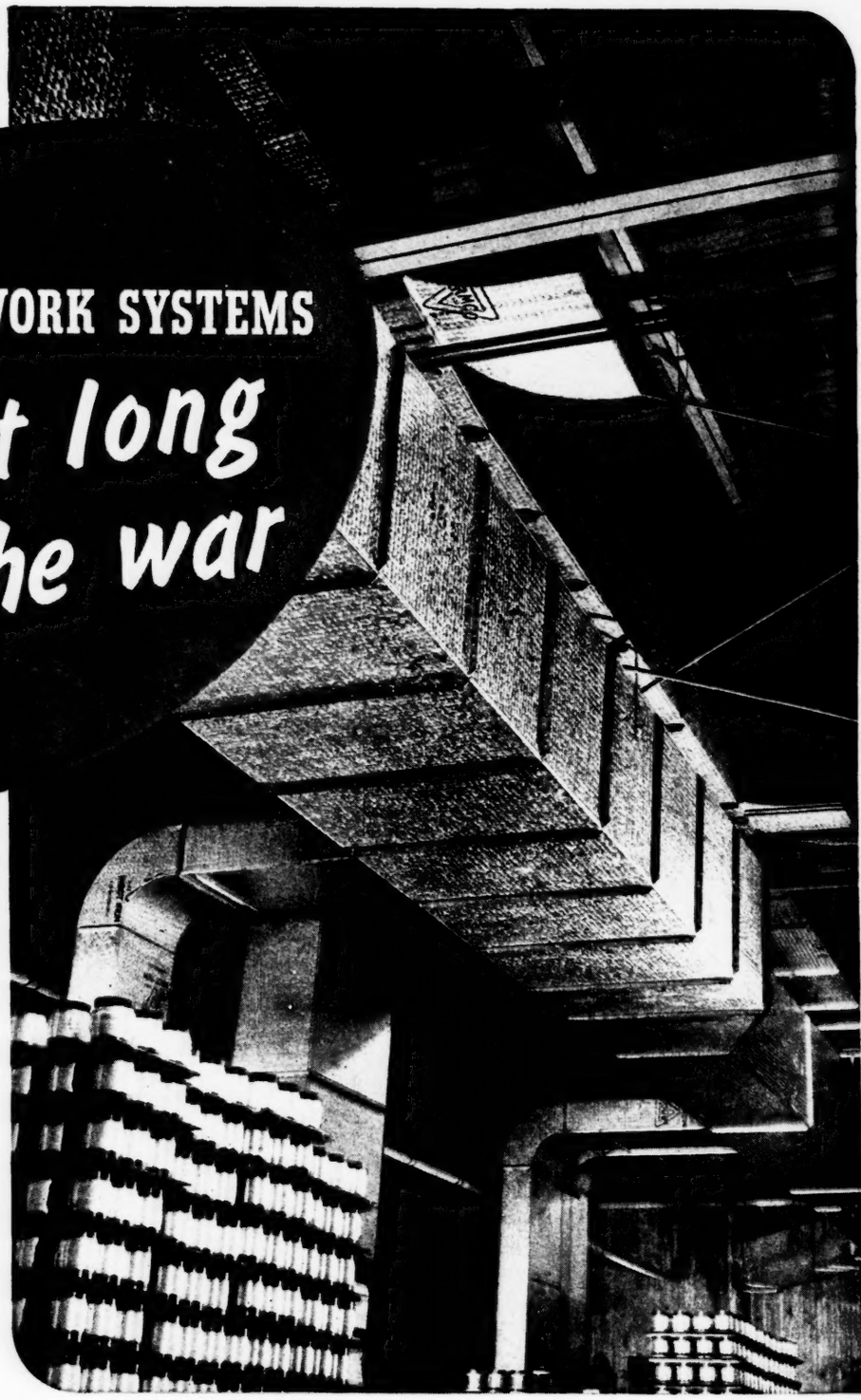
HORIZONTAL DELIVERY MODEL

modine

UNIT HEATERS

MODINE MANUFACTURING COMPANY, 1812 RACINE STREET, RACINE, WISCONSIN

THESE DUCTWORK SYSTEMS will last long after the war



ARMY-NAVY E

In this war of machines, strict accuracy is required. Parts manufactured in one plant must fit parts made in another — often to tolerances of less than 1/1000th of an inch! This means constant temperatures must be maintained to prevent contraction and expansion. Air conditioning is the answer.

Ductwork systems in many of these air conditioned war plants are constructed of galvanized ARMCO Ingot Iron. Engineers and contractors specify this durable metal because it has the longest actual service record of any low-cost iron or steel sheets. Yet with all its durability ARMCO Ingot Iron costs only slightly more than ordinary galvanized sheets.

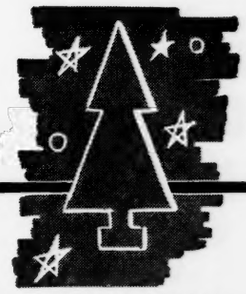
The easy-forming properties of galvanized ARMCO Ingot Iron help contractors maintain exceptionally fast construction schedules. You'll find every sheet is uniform in chemical analysis and in weight of coating.

If you are designing air conditioning systems for war plants write for data on galvanized ARMCO Ingot Iron.* We'll be glad to give you proof of its long life and low maintenance cost. Just address The American Rolling Mill Company, 2461 Curtis Street, Middletown, O.

**For immediate painting and long paint life ask about galvanized* ARMCO PAINTGRIP *sheets.*

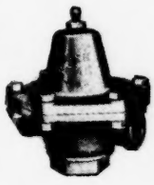
GALVANIZED ★ ARMCO ★ INGOT IRON

THE AMERICAN ROLLING MILL COMPANY



AT THIS TIME OF YEAR ★★★

IT'S *THIS* THOUGHT THAT COUNTS!



A Merry Christmas AND A *Victorious New Year*

TO OUR ARMED FORCES WHO HAVE HONORED US WITH SPECIAL WARTIME ASSIGNMENTS..

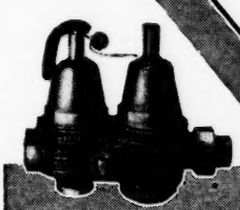
TO OUR MANY CUSTOMERS..BOTH OLD and NEW..

TO ALL WHO HAVE BORNE PATIENTLY OUR INABILITY TO SUPPLY ALL OF THE VALVES THEY WOULD LIKE

★ ★ ★ ★ *Till Victory is Won!*

CASH-ACME

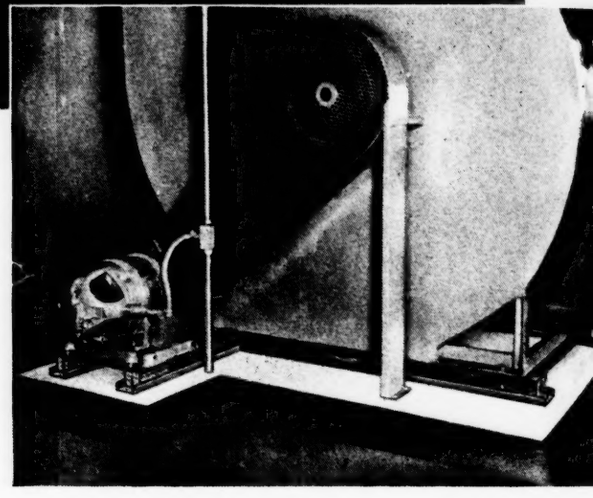
VALVE DESIGNERS & BUILDERS FOR *Over Twenty Years!*



A. W. CASH VALVE MFG. CORP.

DECATUR — WABASH & MORGAN — P. O. BOX 247 (ZONE A) — ILLINOIS

In leading Aircraft Plants...



KORFUND
VIBRATION CONTROL
helps speed production

ABOVE: Korfund Vibro-Bar Integral Base installed under a large fan and motor. Note how the welded steel construction provides an isolation base common to both the fan and its motor, thus maintaining constant alignment between them.

These Aircraft Producers use Korfund Vibration Control:

BELL AIRCRAFT
CESSNA AIRCRAFT
COLUMBIA AIRCRAFT
CONSOLIDATED AIRCRAFT
CURTISS WRIGHT CORP.
DOUGLAS AIRCRAFT
EASTERN AIRCRAFT
HUGHES AIRCRAFT
INTERCONTINENT AIRCRAFT
LOCKHEED AIRCRAFT
McDONNELL AIRCRAFT
NORTH AMERICAN AVIATION
NORTHROP AIRCRAFT
VEGA AIRCRAFT
WRIGHT AERONAUTICAL CORP.

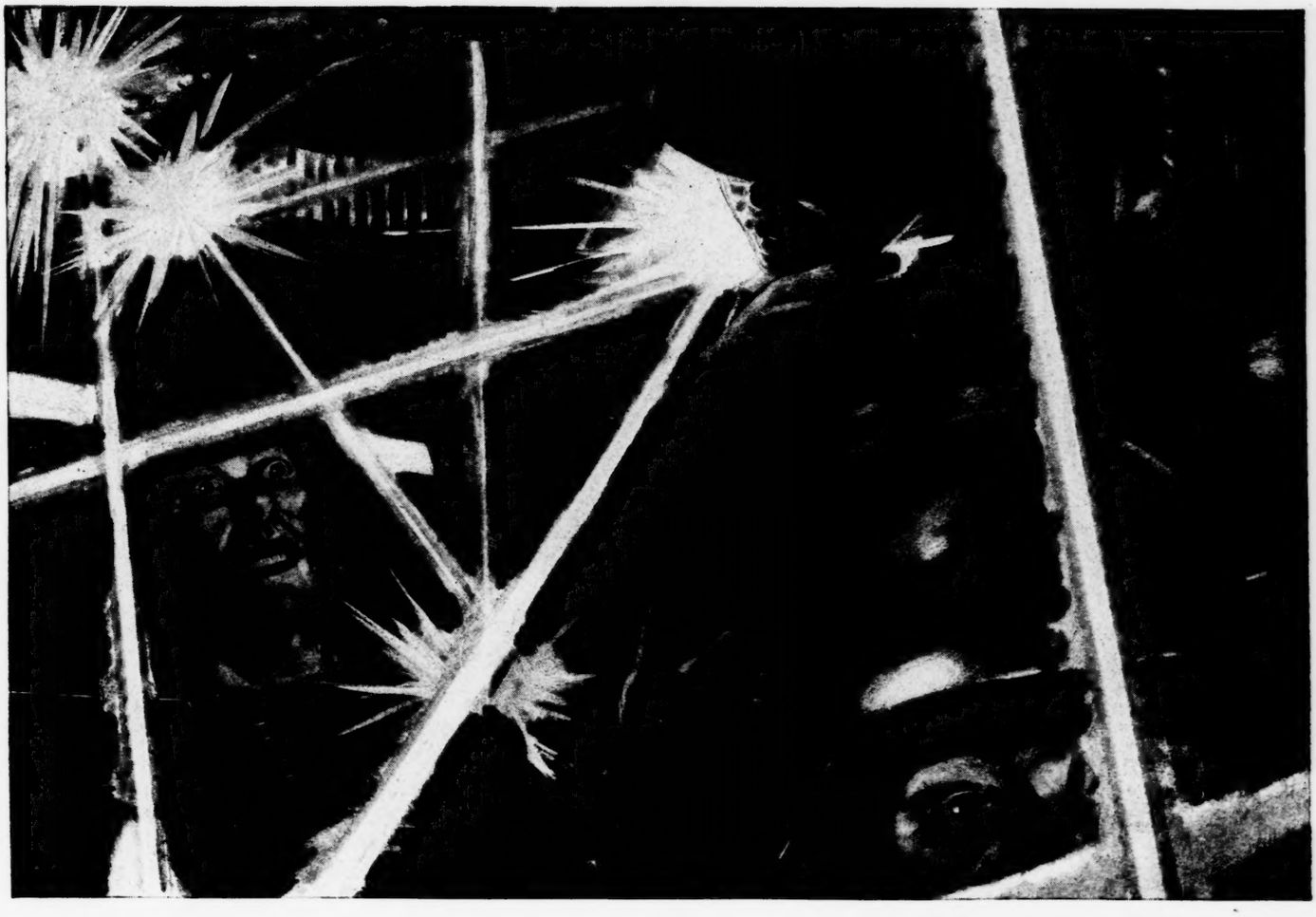
Listed at the left are some of the nation's well known Aircraft Manufacturers who have installed Korfund Vibration Control Equipment in their plants. Realizing the danger of unchecked vibration as a drag on operating efficiency, they are using Korfund equipment to improve personnel efficiency, to increase machinery life, to achieve less spoilage and fewer rejections.

Korfund Vibration Control is applied to any type of reciprocal or rotary machine in such a way as to "isolate" it from the building structure and thus prevent the transmission of vibration. Steel springs, rubber, or cork may be utilized.

Over forty years' experience devoted exclusively to the design and manufacture of vibration-isolation products, plus 250,000 successful installations all over the nation and the world are your guarantee of satisfaction.

Whatever machinery vibration problem may be bothering you, you will find Korfund your answer for economical and successful vibration control. Send for interesting literature or call our representative for consultation.

THE KORFUND COMPANY, INC.
48-33 THIRTY-SECOND PLACE LONG ISLAND CITY, NEW YORK



The shell that plays ping pong inside a tank

HEAT Treating—the process of using controlled temperature to put the pierce into anti-tank gun shells, is gradually sounding the death knell of the once invincible weapon of war. The armor plate of the tank that once shed bullets like rain drops, is being drilled into destruction by modern shot. Not only is the armor being pierced, but as the projectile enters the tank it blunts its drilling nose. Then taking advantage of the very armor it has just entered, it strikes and restrikes inside walls, like a ping pong ball, as many as 500 times.

In many heat treating processes, Trane Equipment is being used to rapidly cool oils and liquids used in quenching. In so doing, Trane Products speed ordnance production and ultimate victory.

Today Trane Air Engineers are sending Trane Equipment to war on every war production front. They are utilizing heat, cold, air movement, moisture control—all the elements of weather itself to help win the battles of production.

Tomorrow these men and this equipment will again turn to peace, using the development of today for the comfort and better living of tomorrow.

TRANE

AIR

THE TRANE COMPANY LA CROSSE, WISCONSIN

TRANE COMPANY OF CANADA, LTD., TORONTO

AIR CONDITIONING · · HEAT TRANSFER · · AIR HANDLING EQUIPMENT

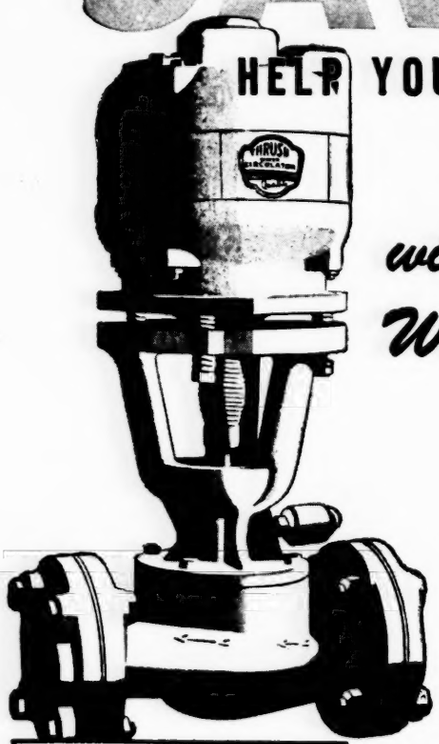
Uncle Sam Says We Must

SAVE FUEL

HELP YOUR CUSTOMERS AND SPEED VICTORY

with **THRUSH**

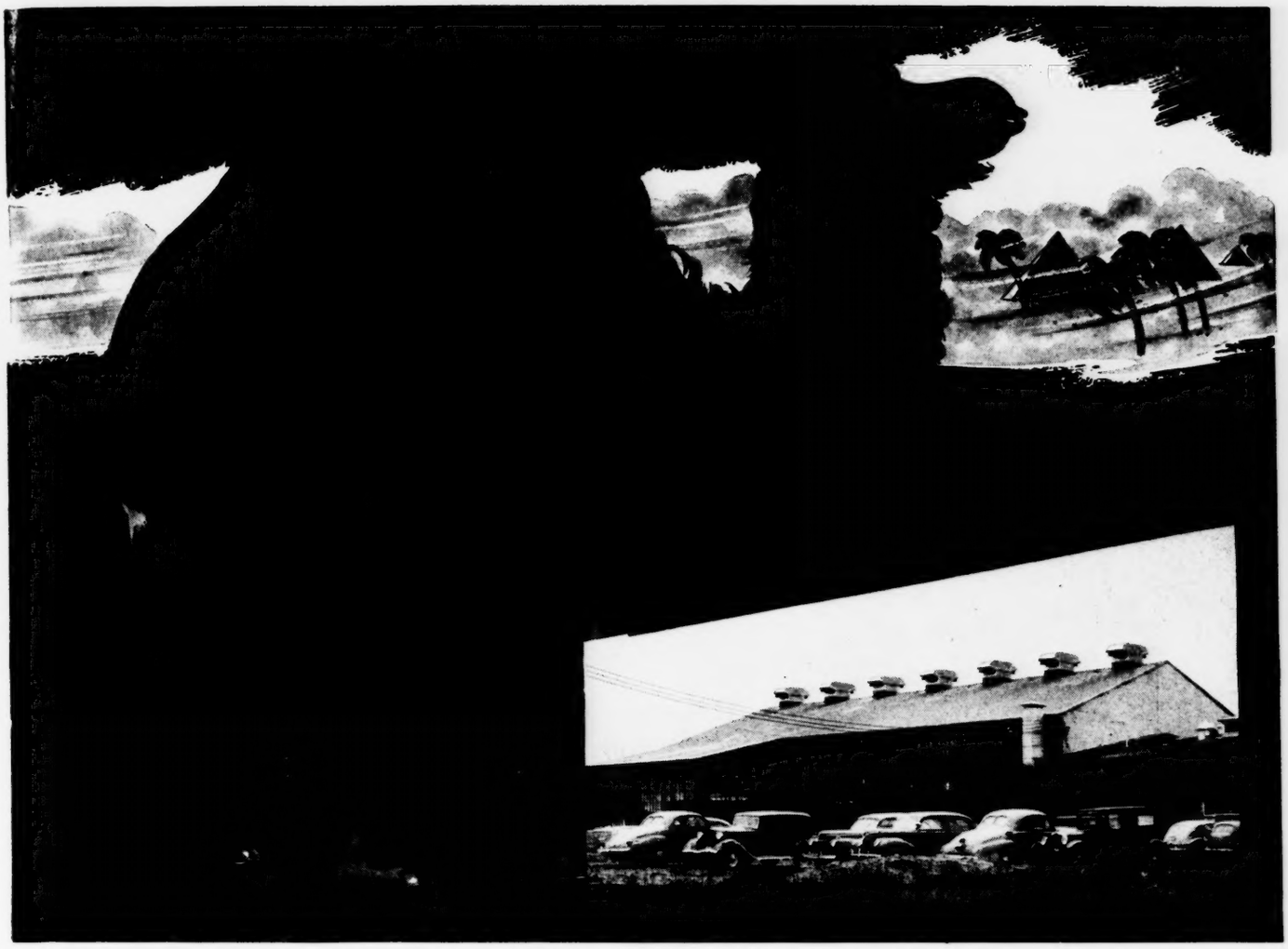
Water Circulators and Controls



THRUSH WATER CIRCULATORS
provide positive, quick heat distribution, save fuel, pipe and fittings.

SAVE FUEL and material for victory! Stop wasteful overheating from poor control of room temperature and uneven heat distribution. You can cure it by installing a Thrush Water Circulator which will assure quick delivery of heat to every radiator through smaller pipe and fittings. Installing a No. 201 Thrush Radiant Heat Control (special heat anticipating room temperature thermostat) to operate the Circulator will give even greater fuel conservation and a constant supply of radiant heat. The War Production Board asks you and us and all engaged in the heating business to immediately initiate a campaign to make heating plants more efficient everywhere. Thrush equipment is the answer. It's up to you to tell home owners in your community about it . . . and get the business. See your wholesaler today or write Department D-12.

H. A. THRUSH & CO., PERU, IND.



A camel would have felt at home in this drop forge plant

Until Allen Engineers Took Over . . .

IN THIS huge structure of the Lindell Drop Forge Company, Lansing, Michigan, under-roof temperature in summer regularly hit 170° to 190° Fahrenheit. Floor working temperatures upward of 120° prevailed. O.K. for camels—tough on men intent on high production. That's how things stood when Allen got the nod to see what could be done about it.

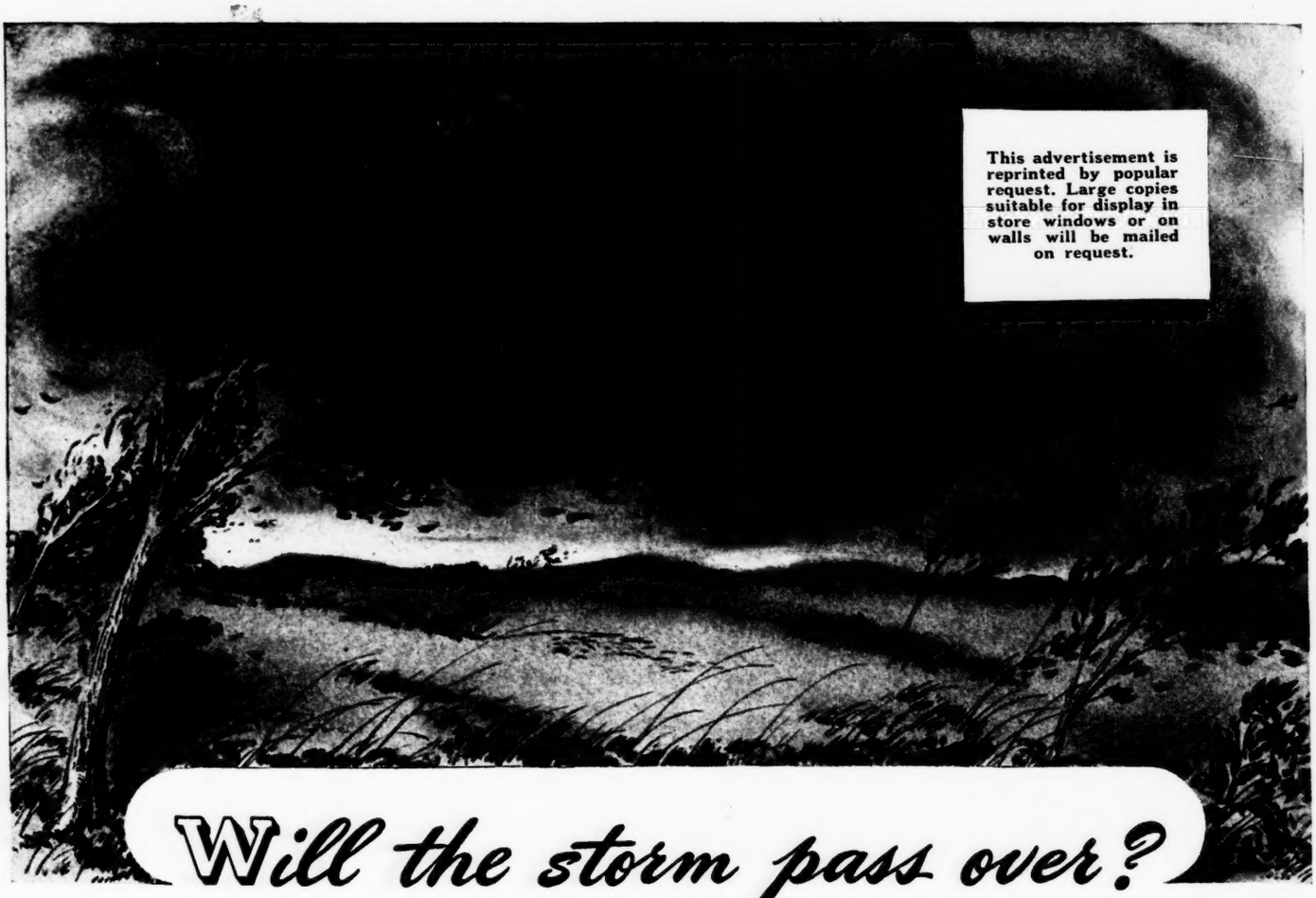
Allen men, wise to the ways of air movement, thoroughly studied the situation, submitted a recommendation based on an objective of complete air-change once a minute. The Lindell management approved and Allen moved ahead. Seven 60 inch cowl ventilators that had been loafing on the job came off pronto. Equally fast, with the cooperation of local sheet metal men, seven 54-B Type "H" Allen Roof Fans went onto the ridge.

Result: complete satisfaction. With 60 air changes an hour, floor working temperatures moved down within reason. And incidentally—fumes and smoke that had been troublesome took to their heels along with the excessive heat.

This is just one case in point, Allen engineers have licked a good many tough ones. The reason is three-fold: experience, the right attitude, the right equipment. They take on ordinary or extraordinary ventilation problems with equal facility. If you have excess heat, dust, fume or moisture conditions, Allen men are ready and willing to take a look-see and tell you what you can do about it. And if you want it done—Allen has the proper gravity and/or power ventilation equipment to do the job and do it right. *The Allen Corporation, 9751 Erwin Avenue, Detroit 13, Michigan.*

THE *Allen* CORPORATION

ENGINEERED VENTILATION FOR INDUSTRY


This advertisement is reprinted by popular request. Large copies suitable for display in store windows or on walls will be mailed on request.

Will the storm pass over?

The approaching storm clouds heralding the depletion of our oil reserves is a matter of deep concern these days.

We hear and read a lot of conflicting reports about the future of the industries which rely for their lifeblood on the continuation of the petroleum supply. Predictions are that the demand for high-octane gas and synthetic rubber, together with the country's dwindling oil reserves, will make oil so scarce and valuable that it will no longer be available for the heating of homes.

Forecasting the early extinction of oil reserves has been going on for many years. At least once in every decade the viewers-with-alarm sound the death knell. It was tolled in the days when kerosene lamps were the principal market. It rang out clearly in the early days of the automobile. In 1914 it was predicted that the oil supply would last only a few years, and in 1919 the forecast was that the last drop would be squeezed from the earth in 1937.

Although war has all but stopped the search for new reserves, attention is being given by Government officials to this all-important problem of locating new sources of the vital fluid upon which we depend for Victory and the industrial progress which has made America great.

Opinions vary as to the amount of our proven reserves, but if petroleum from wells were certain to vanish in the next two decades, synthetics, huge shale resources and imports provide good bets that there will be oil. We have faith in the resourcefulness of the oil industry and of the Government officials who are vested with the responsibility of supplying America with this vital necessity.

It is not yet time to lose faith. We believe there will be oil—gasoline for automobiles and airplanes—and oil for synthetic rubber and for the heating of homes. Even if a large percentage of light fuel oils is required for the manufacture of high-octane gas in the future, burners using the heavier and cheaper grades are sure to be developed.

Detroit Lubricator Company is not losing faith in the future of the oil burner. On the contrary, we are betting the considerable expense of amazing new developments in oil burner controls on a great survival of the oil burner industry. These controls will be far ahead of anything now available.

And we believe there will be a market for them.

DETROIT LUBRICATOR COMPANY *General Offices:* **DETROIT 8, MICHIGAN**

Division of American Radiator and "Standard" Sanitary Corporation

Canadian Representatives—RAILWAY AND ENGINEERING SPECIALTIES LIMITED, MONTREAL, TORONTO, WINNIPEG

"DL" Heating and Refrigeration Controls • Engine Safety Controls • Safety Float Valves and Oil Burner Accessories • Radiator Valves and Balancing Fittings • Arco-Detroit Air and Vent Valves • "Detroit" Expansion Valves and Refrigeration Accessories • Air Filters • Stationary and Locomotive Lubricators

do it...but quickly:

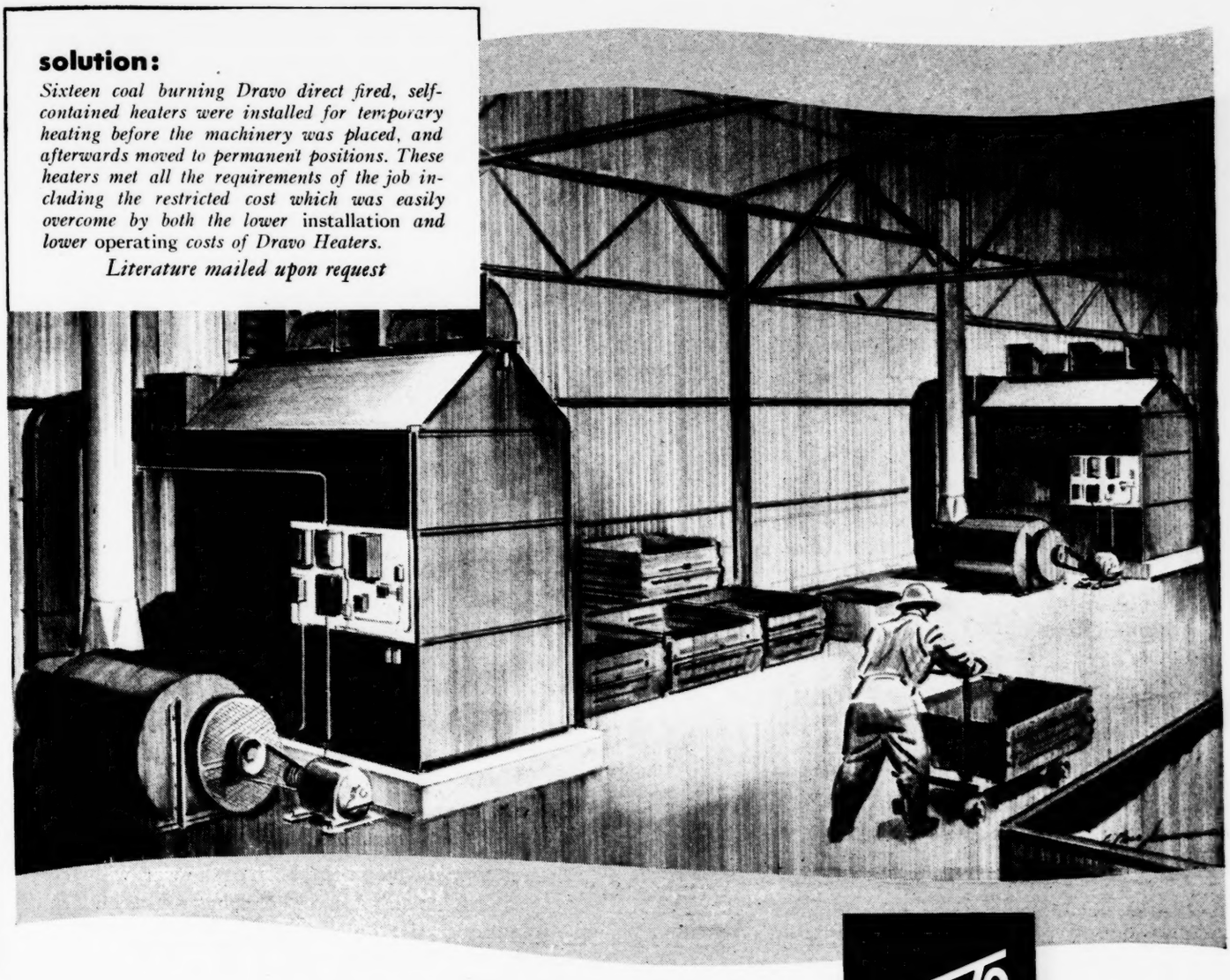
Take a group of Tobacco Warehouses . . . furnish 25,000,000 B.t.u. . . . to facilitate precision machinery work

Several old tobacco warehouses were considered for conversion to the manufacture of precision aluminum aircraft castings. The buildings, varying in size, were light structures without insulation and were widely separated. No oil or gas was available. Heat was required to provide comfortable temperatures for personnel and to eliminate expansion and contraction in the castings. Heat had to be made available before the machinery was installed. A system sufficiently flexible to meet these conditions had to be found, and in addition the rehabilitation contract set an extremely low cost for installation and operation of the heating system.

solution:

Sixteen coal burning Dravo direct fired, self-contained heaters were installed for temporary heating before the machinery was placed, and afterwards moved to permanent positions. These heaters met all the requirements of the job including the restricted cost which was easily overcome by both the lower installation *and lower* operating *costs of Dravo Heaters.*

Literature mailed upon request

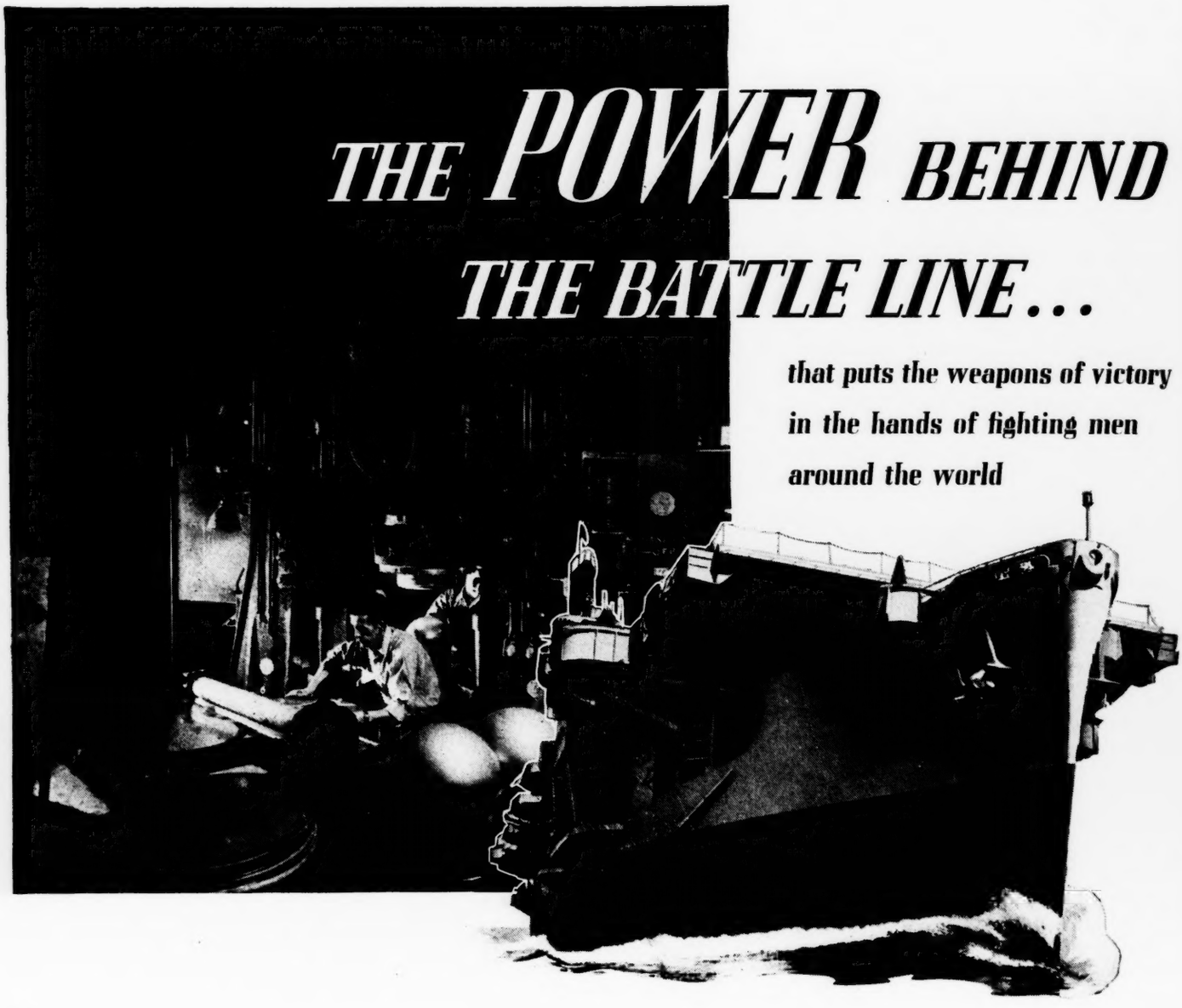


DRAVO CORPORATION · PITTSBURGH

DRAVO heating

THE POWER BEHIND THE BATTLE LINE...

that puts the weapons of victory in the hands of fighting men around the world



Bombers, tanks, shells, bazookas—all the thousand and one items of supply vital to the war—pour out of America's factories in tremendous quantities . . . Ships go down the ways at a rate the world had not even dreamed of . . .

And to back the great attacks now beginning, America's war production must rise to still greater heights this year.

The entire TODD COMBUSTION EQUIPMENT organization is proud to be playing its part in this mighty effort.

For 30 years TODD burners have won for themselves a unique reputation for continuous and efficient production of power and heat, both on land and sea. Since Pearl Harbor, TODD has met, and is now constantly meeting, the enormous demands for efficient combustion equipment for new and converted war plants, and the rapidly growing Navy and Merchant Marine!

All TODD burners today are on high priority. But when victory is won, the company will again serve the many organizations who today cannot obtain combustion equipment—commercial buildings, plants manufacturing civilian goods, churches and schools.

New research development, born of the war, will enable TODD to provide still greater efficiency and economy in boiler plant operation on both land and sea.

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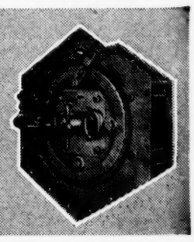
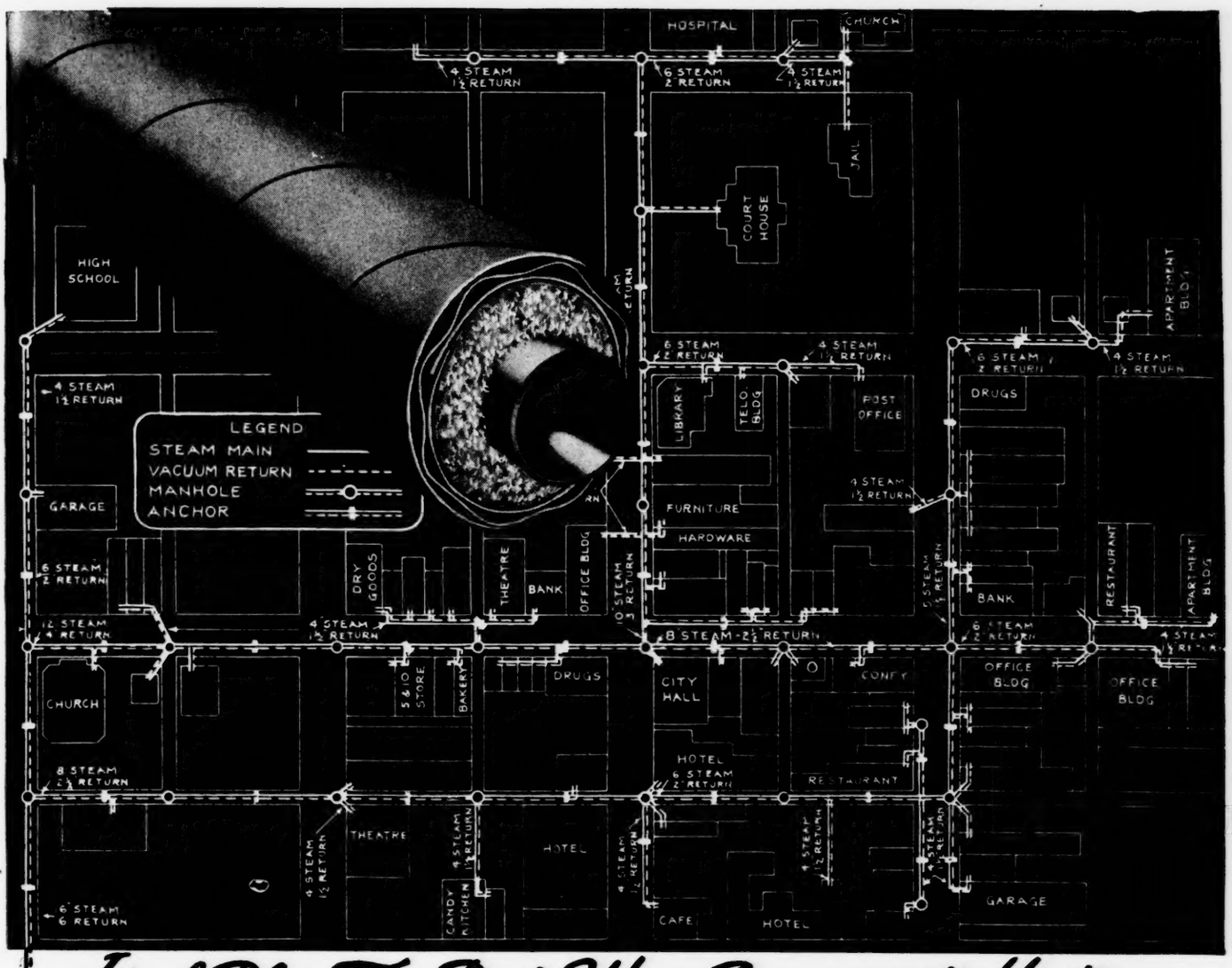
ON THE FIRING LINE OF AMERICA'S WAR PRODUCTION FRONT TODD BURNERS





Ideal Plan For Post-War Community Heating

A CENTRAL HEATING PLANT + RIC-WIL CONDUIT

Outstanding among the advantages of community planning are the benefits gained from central heating—making it possible to purchase *heat* as a commodity like gas, electricity or city water. Ric-wiL Prefabricated Insulated Pipe Conduit provides the most easily installed, dependable, economical and efficient system of heat distribution—proven by more than a thousand miles of all types now in service.

ADVANTAGES OF CENTRAL HEATING WITH RIC-WIL PREFABRICATED CONDUIT

CONSTRUCTION ADVANTAGES:

- Conduit furnished complete with prefabricated field accessories.
- Prefabrication minimizes field work.
- Conduit is accommodated in narrow, shallow trench.
- Minimum excavation and backfill.
- Little or no interference with other construction.
- 21-ft. lengths for speedy installation.
- All-weld construction provides durable, watertight system.
- System is efficient, dependable, maintenance-free.

SERVICE ADVANTAGES:

- Savings of 15% or better in overall fuel consumption.
- Elimination of furnace or boiler tending by consumer.
- Promotes cleanliness in buildings heated.
- Provides extra room in building basements.
- Decreases fire and explosion hazard.
- Reduces smoke and soot, provides cleaner, healthier community.
- Eliminates private coal delivery and ash removal.
- Gives uniform, clean heat quickly, whenever needed.

Write for detailed information on Ric-wiL Conduit for central heat distribution.

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THE RIC-WIL COMPANY · CLEVELAND, OHIO
AGENTS IN PRINCIPAL CITIES

Let this be your contribution to Victory: Make your heating equipment serve longer by good care . . . Conserve fuel by promptly replacing worn-out or inoperative parts.

7-Point Check-up for UNIT HEATERS

Don't wait until something goes wrong. Preventive maintenance pays big dividends in the operation of Unit Heaters, especially today when damaged parts are difficult to replace and every breakdown imperils the success of the war production effort.

Here is a seven-point maintenance check-up designed to help you get best results from your Unit Heaters . . .

(1) Blow dust and dirt from heating coil, preferably with air hose.

(2) Make sure that fan and casing are free of dirt or grease.

(3) Lubricate motor regularly according to manufacturer's recommendations, using best quality lubricants. Keep motor clean.

(4) Tighten motor and support bolts.

(5) Adjust discharge deflectors for best heating results.

(6) Check wiring and electrical connection to thermostatic control, making sure thermostat is clean.

(7) Check the operation of float and thermostatic drip trap, clean thoroughly, replace any parts that are inoperative—float, seat or thermostatic air vent.

Your nearest Webster Representative will help you to eliminate waterlogging or air binding of Unit Heaters. Often a Webster Float and Thermostatic Drip Trap is all you need to secure vastly improved heating results.

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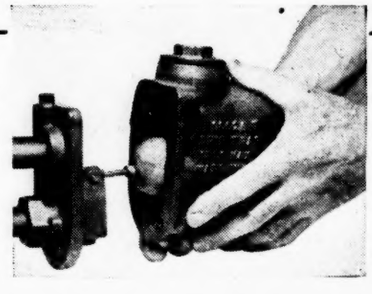
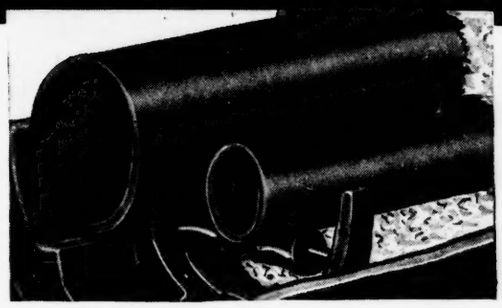


EASY TO INSTALL GROUP OF PIPES



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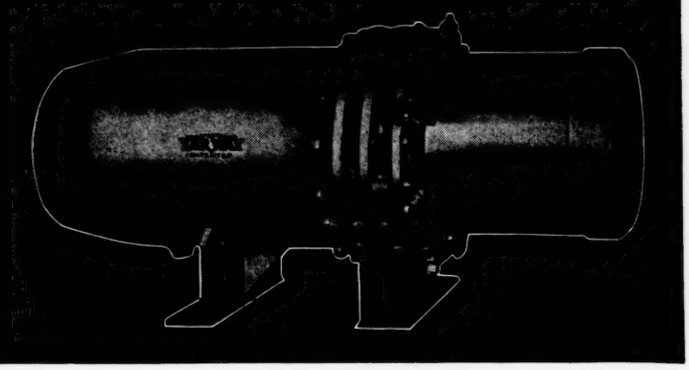

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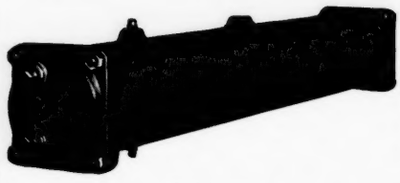

● The "all-in-one" finned copper tubing used in these units is silver soldered to the tube sheet—the tubes are cleanable but not readily removable.

These units are lighter and less expensive than condensers having rolled-in tubes.

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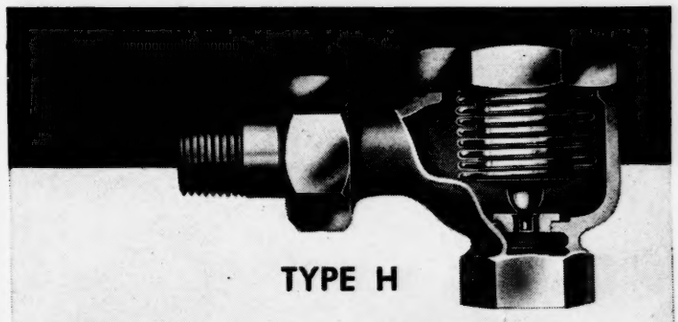

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Clip your name, firm, and address to this ad; tear out with the checked squares above; mail; and you will hear from us promptly.

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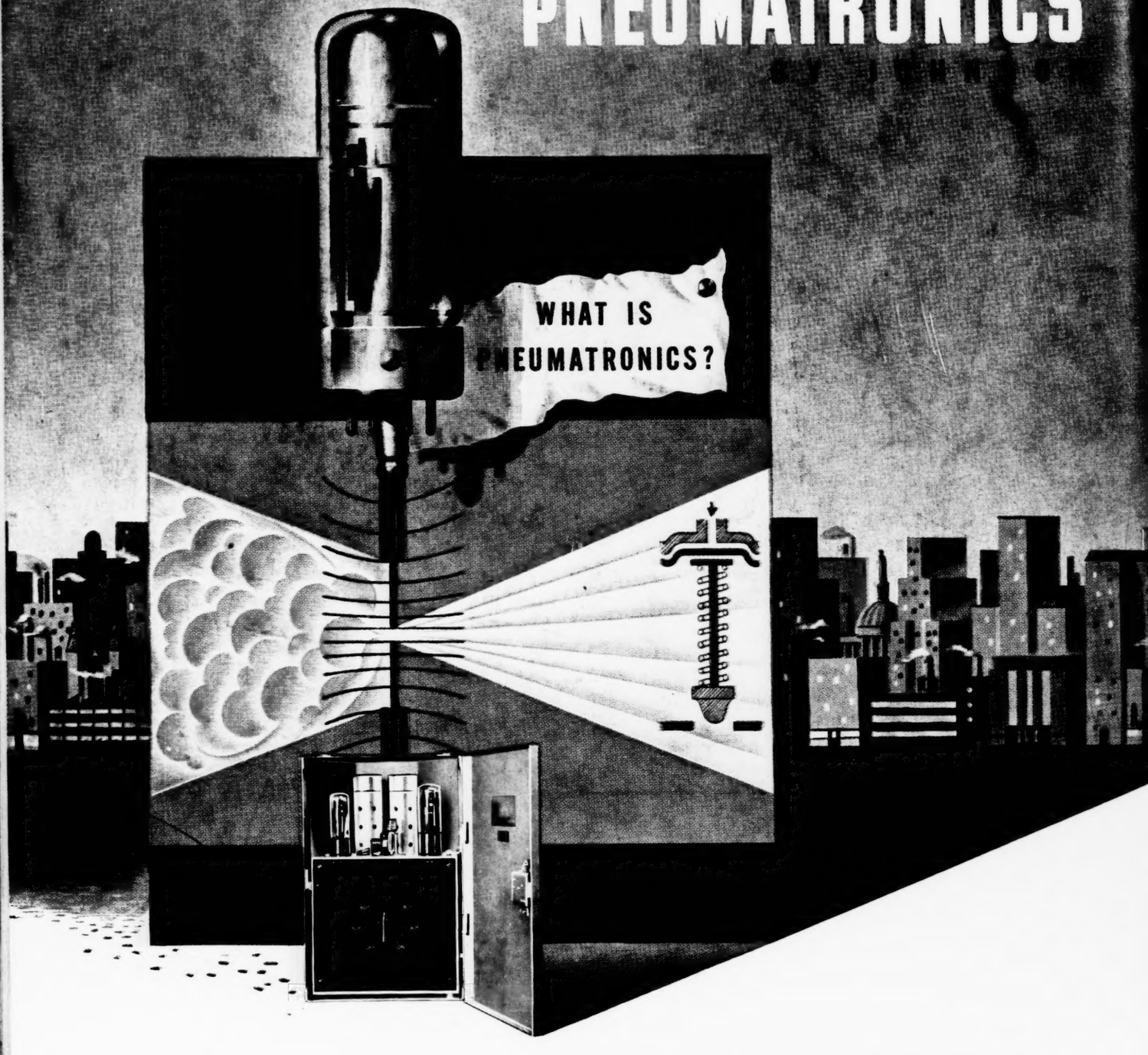

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